UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1175

Washington, D. C. ▼ September, 1923

GRAIN-SORGHUM EXPERIMENTS AT THE WOODWARD FIELD STATION IN OKLAHOMA

By

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Bureau of Plant Industry

CONTENTS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1923

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CONTENTS.

OBJECTS OF THE EXPERIMENTS.

Grain-sorghum experiments have been conducted at the Woodward Field Station in Oklahoma since its establishment in 1914. This bulletin presents the data obtained from varietal, date-of-seeding, and spacing experiments with grain sorghums during the eight years from 1914 to 1921, inclusive.

Climatic factors are recognized to be the determining influence in the agriculture of the Great Plains area, the southern part of which may be considered as the grain-sorghum belt. It is because of the adaptability of the sorghums to droughty conditions that they are so extensively grown in the southern Great Plains. The objects of the experiments herein described were (1) to determine the response of the different varieties of grain sorghums to the climatic and other environing conditions and (2) to determine the behavior of the principal varieties of grain sorghums when certain factors under control of the grower were varied.

[1] This manuscript was submitted for publication March 10, 1923.

The writer desires to acknowledge his indebtedness to E. F. Chilcott, superintendent of the Woodward Field Station, for cooperation in providing every facility for the conduct of the experiments here reported and for many valuable suggestions.

For varietal and cultural experiments to be of more than local application, it is necessary to describe in detail the physical conditions which existed at the place where the experiments were conducted. This description of environing conditions is especially necessary with the grain sorghums, as they are grown in an area in which climatic factors are the determining influence in their production.

DESCRIPTION OF THE WOODWARD FIELD STATION.

LOCATION.

The Woodward Field Station consists of 310 acres of bench land 1 mile southwest of Woodward, Okla. The elevation is approximately 1,900 feet above sea level. Woodward is centrally located in

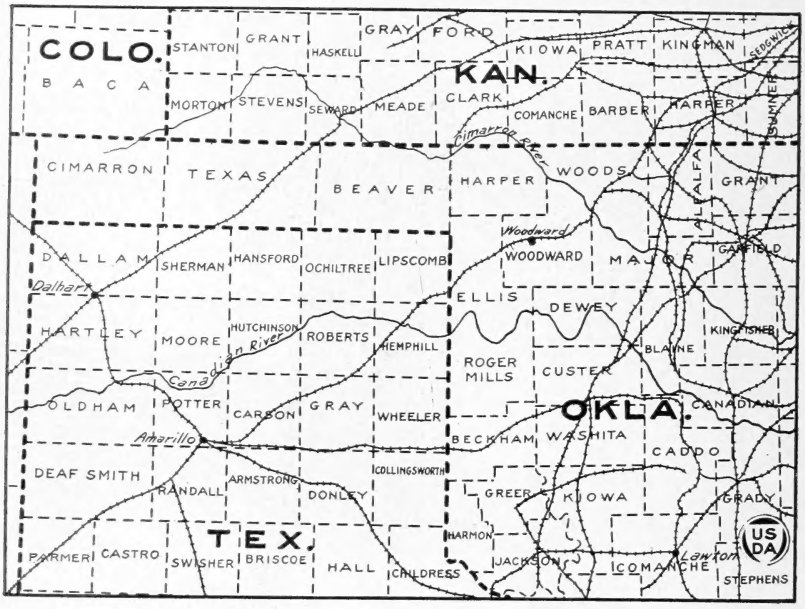

FIG. 1.—Sketch map of western Oklahoma and portions of adjoining States, showing the location of the Woodward Field Station and the section to which the results reported in this bulletin are generally applicable.

the transition section extending north and south between the high plains to the west and the prairies of the central lowlands to the east. The location of the station is shown in Figure 1. Figure 2 presents a general view of the station buildings and part of the plats.

The station farm slopes to the northeast and is drained in that direction to the North Fork of the Canadian River through several dry washes or draws.

SOIL.

The soil of the station is a light phase of sandy loam, classified as Canadian sandy loam. The subsoil consists of sand at a depth of 2 feet, extending to a depth of 4 to 10 feet, where the original residual red material is reached. The surface soil is very porous, and no

run-off occurs except during torrential rains. The soil under optimum tilth contains 8 to 12 per cent of moisture, which can be reduced by plants to a minimum of about 2 per cent. The soil has a tendency to blow, and tillage methods must be employed to prevent blowing or drifting.

CLIMATIC CONDITIONS.

The weather data presented were recorded either by the observer of the Weather Bureau at Woodward, Okla., or by a representative of the Office of Dry-Land Agriculture Investigations at the Woodward Field Station.

The principal climatic factors which influence crop production in this vicinity are (1) a limited and variable annual precipitation, of irregular seasonal distribution; (2) a relatively low atmospheric humidity; (3) a high rate of evaporation during the summer months; (4) a wide daily range of temperature, hot days being followed by cool nights; and (5) a high average wind velocity.

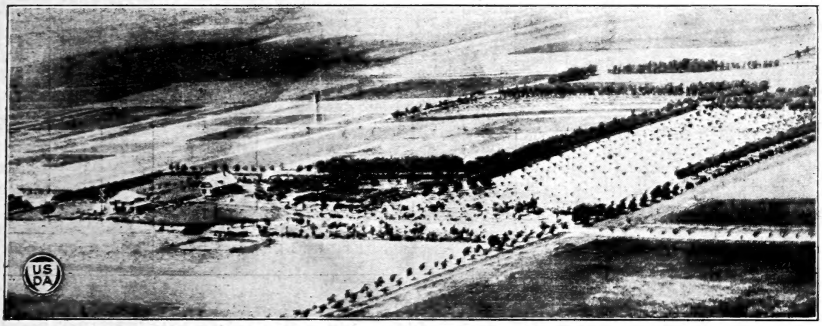

FIG. 2.—Airplane view of part of the Woodward Field Station. Photographed in May, 1920.

PRECIPITATION.

Precipitation and its distribution may be considered the limiting factor in crop production at Woodward, Okla. The total precipitation is usually sufficient to produce a good crop every year, but the distribution is frequently such that soil moisture is lacking at the critical period of plant growth. When this condition exists crop yields are low. During the eight years from 1914 to 1921, inclusive, there have been several seasons of poor rainfall distribution, yet the sorghums produced some grain, though yields were low.

MONTHLY AND ANNUAL PRECIPITATION.

Table 1 shows the monthly, annual, and mean annual precipitation, in inches, at Woodward, Okla., during the 27-year period from 1895 to 1921, inclusive. The mean annual precipitation at Woodward for this 27-year period was practically 24 inches, of which 17.4 inches fell during the growing season, or from April to September, inclusive.

Table 1 shows in a general way the precipitation characteristic of the locality around Woodward. In the 27-year period there were 7 years in which the annual precipitation was less than 20 inches, two of which occurred during the period covered by these experiments.

The extreme range of annual precipitation during the 27-year period reported in Table 1 is from 14 inches in 1910 to 39 inches in 1915.

TABLE 1.—*Monthly and annual precipitation at Woodward, Okla., during the 27-year period from 1895 to 1921, inclusive.*

[Data (in inches) furnished by the United States Weather Bureau. T=trace. *=Data interpolated from near-by stations.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1895	*0.90	*2.00	*0.10	*1.25	*1.60	*5.50	*4.00	*5.25	*0.70	0.50	1.13	1.11	24.04
1896	1.04	.02	.10	3.67	.81	5.30	1.70	1.00	*3.00	*3.10	*.35	*1.75	21.84
1897	2.24	.60	.70	1.08	3.71	1.16	.52	5.21	2.11	*1.25	*.05	*.50	19.13
1898	*1.40	*1.50	*1.20	*1.25	*5.75	*4.75	*4.25	*3.60	*1.40	1.70	.44	*2.65	29.89
1899	*.25	*.20	*1.00	.49	2.91	3.95	4.16	.70	4.00	2.25	1.60	.58	22.10
1900	.54	.71	*.50	*5.00	*2.60	*2.90	*2.10	.70	5.11	.97	T	T	21.13
1901	.50	T	.51	6.15	4.06	0	1.49	1.75	1.65	2.05	0	0	18.09
1902	.15	*.20	*1.50	*1.75	*10.00	*1.90	*2.30	*.90	*.90	*1.25	*1.50	*.90	23.25
1903	*.05	*3.25	*1.25	*1.75	*6.15	*2.00	*1.00	*2.10	.65	1.15	.32	*T	19.67
1904	T	T	1.00	*1.75	*2.50	4.97	7.31	2.95	1.62	*.75	.10	*1.25	24.20
1905	.60	.25	1.20	*4.00	1.13	2.00	*4.50	1.30	2.00	*.70	1.04	.03	18.75
1906	*.75	*.40	*1.75	*2.30	*2.50	*3.80	*5.90	*4.00	*2.75	*4.00	*2.60	*.80	*31.55
1907	*2.50	*.25	*.20	*2.00	*2.00	*4.75	*2.75	*6.00	*.90	*2.65	*.60	*2.10	*26.70
1908	*.25	*1.25	*1.10	*1.70	*3.25	3.76	5.87	1.82	4.30	2.75	1.47	0	27.52
1909	.05	.28	.65	.45	4.78	2.45	1.54	.29	4.88	2.95	9.54	.15	28.02
1910	.46	.22	T	1.97	.53	1.17	1.62	7.65	T	.38	0	.01	14.01
1911	T	8.09	0	.10	4.13	0	3.54	5.29	.41	.82	.52	2.90	25.80
1912	.03	2.58	2.37	1.63	1.15	3.02	3.25	2.90	3.44	.50	.06	.07	21.00
1913	.40	2.44	.54	1.11	2.08	5.31	.99	1.87	4.89	1.05	3.50	2.73	26.91
1914	.18	.51	.34	2.44	3.53	.60	.92	2.92	.82	1.99	.06	.77	15.08
1915	1.17	3.44	1.45	7.08	6.47	2.87	3.46	3.90	6.27	2.52	.56	.02	39.21
1916	1.29	.03	.92	2.01	1.74	11.64	0	1.15	2.22	1.87	.95	38	24.25
1917	.43	.22	.34	1.93	1.39	1.89	1.33	7.00	1.90	0	.77	.18	17.38
1918	1.60	.22	1.85	2.51	4.49	2.11	1.79	.70	1.26	3.54	1.73	3.58	25.38
1919	.06	1.46	1.60	4.87	4.63	3.76	1.91	1.72	.56	2.75	4.54	0	27.86
1920	.92	T	.82	1.12	4.19	1.31	5.44	2.62	6.34	2.88	.62	2.04	28.30
1921	1.85	1.02	1.70	1.85	1.55	8.00	3.15	6.85	2.90	.05	0	.30	29.23
Average	.73	1.15	.91	2.34	3.32	3.37	2.84	3.04	2.48	1.72	1.26	.92	24.08

The extreme variation in precipitation for any month during the growing period illustrates the irregular distribution of rainfall. During April, 1911, there was but 0.1 inch of rainfall, while in April, 1915, there were 7.08 inches. In May, 1910, 0.53 inch of rain fell while in May, 1915, there were 6.47 inches. No precipitation occurred during the month of June in 1901 and in 1911, and in June, 1914, there was but 0.6 inch, while in June, 1916, there were 11.64 inches and in June, 1921, 8 inches. No rain fell in July, 1916, while in July, 1904, there were 7.31 inches; in 1908, 5.87 inches; and in 1920, 5.44 inches. The variation for August was from 0.29 inch in 1909 and 0.7 inch in 1918 to 7.65 inches in 1910 and 7 inches in 1917, while the variation for September was from nothing in 1910 to 6.34 inches in 1920.

DISTRIBUTION OF MONTHLY PRECIPITATION.

Figures showing only the monthly precipitation for a locality in the southern plains area do not give a complete view of the moisture conditions. The total monthly rainfall has sometimes been sufficient to produce large crops, yet it came at such intervals that long periods of drought occurred which damaged growing crops. To illustrate this fact and to show as nearly as possible actual moisture conditions during the various seasons, daily and monthly precipitation records for the eight years covered by these experiments are given in Table 2.

TABLE 2.—*Daily and monthly precipitation at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

[T=trace. Data (in inches) furnished by the Office of Biophysical Investigations, Bureau of Plant Industry.]

Year and date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1914:													
1					1.96	T	0.08						
2				0.04			T						
3				.12			.02						
4					.01					0.01			
5		0.04	T	.20		T		0.40	0.16				
6				.11	.01		1.45			1.20		0.27	
7										.04			
8													
9								.88					
10	0.18			.55	.11								
11				.04					.01	.22			
12		.02							.07				
13		.08							T				
14													
15					.31	0.61			.29				
16					.01	T							
17		.25		.17	.01								
18		.12		.02	.22		T						
19			T				T						
20					T								
21			0.05						.03				
22				T									
23				.15				.09					
24			T				.33			.06			
25										.07		.08	
26				.25	T								
27	T			T	.11			.30					
28			T		.21			.67					
29	T		T	.03				.28				.17	
30			.28	T	.13			.02					
31					.07								
Total	.18	.51	.33	1.69	3.16	.61	1.88	2.64	.56	1.60	0	.52	13.68
1915:													
1		.28			.13	.03	.59	.09					
2			.67		T	.04	T						
3			.18			T	.63			T			
4		.02	.37		.09	.43							
5		T			1.10	.01			.06			.02	
6		T	T	1.10	.04	.16							
7				1.71				1.37					
8			T	.35			.40	1.50	T				
9			T	1.04				.04					
10	.80							.08	.32		0.50		
11	T									.34			
12		T								T			
13		T						.10	.77				
14									.89	.98			
15			.07			T		T	.15	.99			
16	.05				.03					.05			
17		T		.04	.09					T			
18				.12	.78								
19	T		T	.95	.49			.01	.32				
20		.89			.28	T			T				
21		.61	T	.04									
22		.40	.08	.08		.46							
23					.96	.44							
24	T			.85			T		1.00			T	
25	T			.02	.76			.43	.73		.05		
26	T				.22	T							
27	T	.94			.32	T							
28	T	.30				.67	1.30		T				
29	.19		.06	.23		.19			1.32			.04	
30	.12		.02		T		.17		.18				
31							.05						
Total	1.17	3.44	1.45	6.53	5.29	2.43	3.14	3.62	5.74	2.36	.55	.06	35.78
1916:													
1					.01								
2													
3	.14												
4				.32		4.70							
5				T		.33							
6				.48		.11			T				
7	T							.56	.48		.42	.10	

TABLE 2.—*Daily and monthly precipitation at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive*—Continued.

[T=trace. Data (in inches) furnished by the Office of Biophysical Investigations, Bureau of Plant Industry.]

Year and date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1916—Continued.													
8						T		0.18	T		0.03		
9						0.44							
10		T	T	T									
11						.12			1.39	0.27			
12	T	T											
13		T		0.13	T	1.58						T	
14				.50						1.33			
15						.09							
16						.06							
17					0.23	.75			T				
18	T								.03				
19	T					.16							
20												0.30	
21	0.33							.05			.30		
22		0.03	T					T					
23	T		T						.44	.08			
24			0.35			1.92							
25	.75			.35		T							
26	.12				.56			.17					
27	.16	T			T					.03			
28					.90								
29	T	T						.06					
30	T		T	T								.20	
31			.47										
Total	1.50	.03	.82	1.78	1.70	10.26	0	1.02	2.34	1.71	.75	.60	22.51
1917:													
1			T			.25	.68		.09				
2							.04						
3							.10						
4													
5					T		.01						
6								1.82					
7						T		.07		.03		.01	
8								.06					
9					.07				.36				
10					.07		T	.36					
11				.28				.55	.12				
12			.06					.81	.10				
13			.04		.25								
14	.20	.20		.16			T	T					
15	T							.99	.73				
16								.05			.60		
17							.14		1.26		.05		
18		T		.52	T		.16		.06		.01		
19					.32	.16						T	
20						.64							
21					T								
22						.29		.83					
23												T	
24					.08			.03					
25				.04									
26			T		.24								
27				.02				.81			.01		
28						.03		.27		.02			
29				.56									
30													
31													
Total	.20	.20	.10	1.58	1.03	1.37	1.13	6.65	2.72	.05	.67	.01	15.71
1918:													
1			.18				.07		.04				
2			.86						.09		.01		
3			.04						.56				
4						.01			.01				
5				.44	.03				.18				
6					T	.50					.82		
7						.75		.03			.03		
8		T			.02			T					
9							.04			.03			
10	.09	.13											
11	.38	.01			.32								
12				T								.14	
13				.06									
14	T			1.15			.02						

TABLE 2.—*Daily and monthly precipitation at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive*—Continued.

[T=trace. Data (in inches) furnished by the Office of Biophysical Investigations, Bureau of Plant Industry.]

Year and date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1918—Continued.													
15							0.51		0.12		0.07		
16	0.93			T	0.12		.01						
17				0.14								0.62	
18				.35						0.44		.30	
19	.06			.07						.02		.86	
20				.01									
21							.04			1.65			
22					.04		.04	1.05		.22		.80	
23								.01					
24						T							
25					.24				.18	.75	.65		
26		T			.09	0.22			.06	.24			
27	T	0.15			.57	.03							
28	.14		0.60		2.32	.03	T						
29			.41			.37		.26					
30					.25							.20	
31													
Total	1.60	.29	2.09	2.22	4.00	1.91	.73	1.35	1.24	3.35	1.58	2.92	23.28
1919:													
1		.23		.04	.61		T	.16					
2				.11	.01								
3				T						.37		T	
4										.05			
5										.08		T	
6				.03	.02			.78					
7			.25		.08	.35		.02		.83			
8				1.61	T					.05	1.40		
9			.50	.15		.69				.02	.10		
10					.41	.04							
11					.06	T							
12		.28			T					T			
13	T	.12				.05		T					
14	.06		.03		.09	.08	.72			.34			
15			.20			.16	.07		.01				
16			.27				.23		.01	.01			
17			T				.03	.54	.61				
18					.06		.30						
19		.40						.11					
20													
21		.50	T										
22						.05							
23			.65			.80							
24			.04	.14	1.83						T		
25				1.09	.13					T			
26				.44	.21					.06	.71		
27				.19	.13								
28					.03			.06		T	.16		
29								.20		.04			
30			T	.30	.07					T			
31			T		.55		T						
Total	.06	1.53	1.94	4.10	4.29	2.22	1.35	1.87	.63	1.85	2.37	T	22.21
1920:													
1				T	.02	.02	.73		.39				
2		.07					1.56		.33			T	
3				.10		.26			2.32				
4	.10					.01	.21	.28	T				
5	.03				T		.91	.07	.39			.46	
6			T						1.46		.57	.92	
7							.28		.04		.30		
8					.01		.59		.02		.01		
9	.90				.04		.16	.15	.01				
10			.02	.33	1.06			.69	.05				
11			.12				.10	.11			.03	T	
12								T			T	.07	
13					T							T	
14					1.28								
15					.06								
16				T	.01	.30	.02						
17				.02		.28		1.08					
18				.22		.18		.09					
19						.09		.01		.70			
20					.01	.04		.02		.10		.08	
21		T				.03				1.29			

TABLE 2.—*Daily and monthly precipitation at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive*—Continued.

[T=trace. Data (in inches) furnished by the Office of Biophysical Investigations, Bureau of Plant Industry.]

Year and date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1920—Continued.													
22													
23													
24				0.01						0.07			
25			0.27	.25									
26			.20	.13				0.24			0.15		
27					0.41		0.03	T	T		T		
28					.49		T				T		
29					.01			.14			.25		
30											.01		
31						0.08				.08			
Total	1.03	0.07	.61	1.06	3.40	1.29	4.69	3.00	5.01	2.55	1.32	1.53	25.56
1921:													
1													
2		T						T		T			
3				T		.45						.04	
4				.08		.52						.02	
5				.62		.51	.63						
6		.01		T	.01	.96				T		T	
7		.01				.97			2.80	T		.03	
8	T					.01						.02	
9												T	
10					.53		.28	.22					
11					T		.94	.74					
12				T	.01			2.45	.03				
13			.28	.71	.78	.43		1.49					
14				.19	.05	.07		.21					
15			T	T	T	.11		T				T	
16				T				T					
17		.14			T				T				
18		.45				.07	.19		.10				
19						1.22			T				
20			.88			.01							
21	.09		.13	T		.26							
22	1.37					.18							
23	.76					.01							
24				.09			.42		.01				
25				.01			.04						
26			.03		.01								
27				.01									
28			.01	.09									
29										.01			
30					.02					T			
31					.50								
Total	2.22	.61	1.33	1.80	1.91	5.78	2.50	5.11	2.94	.01	0	.11	24.32

During each of the eight years these experiments have been conducted the total annual and seasonal precipitation has been sufficient to produce high yields of grain sorghums. During some of the years the monthly rainfall appears to have been sufficient to warrant high yields, yet in practically every year a droughty period has occurred which caused a reduction of the yields of some varieties. It is because of dry periods occurring in months which show sufficient rainfall to produce good yields that Table 2 is indispensable in presenting actual conditions.

LOCAL VARIATION IN PRECIPITATION

Much of the summer rainfall of this vicinity comes in the form of local thundershowers. The variation in rainfall at two near-by points is well illustrated in Table 3. This table shows the precipitation recorded by the United States Weather Bureau observer at Woodward and that measured at the Woodward Field Station during six

growing months in the years 1918 to 1921, inclusive. The distance between the two points of observation is about 1½ miles, the Weather Bureau records being taken in the town, which is located in the valley of the North Fork of the Canadian River. It is to be noted that the rainfall at the Weather Bureau station averages higher than that at the field station, which is due to the fact that many of the summer showers follow the river valley. Frequently, good showers occur in town when little or no rain falls at the field station, which is situated on higher bench land.

TABLE 3.—*Precipitation at the United States Weather Bureau station, Woodward, Okla., compared with that at the Woodward Field Station during the 6 months from April to September for the years 1918 to 1921, inclusive.*

[Data in inches.]

Year and station.	Apr.	May.	June.	July.	Aug.	Sept.	Seasonal.
1918:							
United States Weather Bureau	2.51	4.49	2.11	1.79	0.70	1.26	12.86
Woodward Field Station	2.22	4.00	1.91	.73	1.35	1.24	11.45
1919:							
United States Weather Bureau	4.87	4.63	3.76	1.91	1.72	.56	17.45
Woodward Field Station	4.10	4.29	2.22	1.35	1.87	.63	14.46
1920:							
United States Weather Bureau	1.12	4.19	1.31	5.44	2.62	6.34	21.02
Woodward Field Station	1.06	3.40	1.29	4.69	3.00	5.01	18.45
1921:							
United States Weather Bureau	1.85	1.55	8.00	3.15	6.85	2.90	24.30
Woodward Field Station	1.80	1.91	5.78	2.50	5.11	2.94	20.04

The precipitation data given in Table 1 are those recorded at the Weather Bureau station, as they are available for a greater period of years than the field station records. It must be remembered that the precipitation data given in Table 1 are somewhat high for the conditions under which the experiments were conducted. The data in Table 2 were obtained at the field station and show precipitation conditions under which the crops were actually grown.

HUMIDITY.

The atmospheric humidity of this section is usually low. Humidity decreases and wind velocity increases from central Oklahoma westward. The relatively low humidity at Woodward is doubtless correlated with high transpiration from growing crops, as low humidity is one of the chief factors favorable to high evaporation. The relative atmospheric humidity has been determined from wet and dry bulb readings taken at the Woodward Field Station during the six months from April to September, inclusive, for the eight years in which these experiments have been conducted. The relative atmospheric humidity is given in Table 4, together with other climatic data.

WIND.

Data on wind velocity are shown with other climatic data in Table 4 for the crop season (April to September) during the 8-year period from 1914 to 1921, inclusive. The wind velocity for the season averages high. Some days are calm, followed by days of high wind movement. The highest wind movement for one day during the period reported was 608 miles, on April 11, 1920. This is an average of more than 25 miles an hour for 24 hours. These wind data were recorded by an anemometer at the field station

standing 2 feet above the surface of the ground and represent closely the movement of wind actually sweeping over the surface of the land. Winds of this velocity can cause great damage to crops by covering the young plants, cutting them off with moving sand particles, or causing the crop to lodge when mature or nearly so.

TABLE 4.—*Relative humidity, temperature, and wind movement recorded at the Woodward Field Station in the 6 months from April to September, inclusive, during the 8-year period from 1914 to 1921, inclusive.*

Year and month.	Relative humidity.[1]	Temperature.					Wind.			
		Mean.	Maximum.		Minimum.		Prevailing direction.	Monthly movement.	Highest day.	
			Reading.	Date.	Reading.	Date.			Movement.	Date.
1914:	*Per cent.*	°*F.*	°*F.*		°*F.*			*Miles.*	*Miles.*	
April	50.5	58	97	16	24	[2] 8	N	7,344	440	22
May	62.1	66	92	10	42	[2] 12	S	6,845	400	9
June	49.4	81	104	28	61	16	S	7,920	463	6
July	48.6	83	104	[2] 15	61	8	S	4,613	298	21
August	55.2	79	100	20	60	27	S	4,836	316	22
September	46.9	75	98	5	44	29	S	5,688	331	12
1915:										
April	56.9	60	88	28	31	2	S	6,768	481	3
May	61.4	62	92	13	37	6	E	5,952	413	24
June	64.1	73	99	20	47	[2] 6	E	5,544	351	10
July	60.1	78	100	12	55	4	S	5,580	341	6
August	70.5	72	97	7	45	29	E	3,050	189	6
September	69.3	[3] 71.5	99	10	[3] 46	[3] 27	S	4,248	302	12
1916:										
April	57.8	54	88	11	22	8	SW	6,624	445	18
May	48.5	69	105	7	40	2	SW	6,770	446	9
June	62.0	73	100	1	53	5	E	5,976	478	21
July	48.9	82	102	18	58	[2] 6	S	4,241	235	1
August	48.1	82	103	[2] 3	50	27	SW	5,506	287	9
September	55.4	70	97	10	36	28	SW	5,904	464	30
1917:										
April	57.1	54	86	22	25	1	NW	8,237	504	15
May	55.1	61	98	17	32	7	SW	6,653	475	16
June	39.7	78	110	12	42	1	S	6,720	495	10
July	46.1	84	110	13	60	[2] 1	SW	5,597	300	28
August	63.6	76	102	4	49	28	SE	3,774	234	4
September	64.3	72	100	7	41	26	SE	3,257	247	24
1918:										
April	61.3	51	79	1	30	9	NE	5,678	360	13
May	52.9	71	101	8	38	9	SW	8,129	462	18
June	54.1	81	106	24	59	[2] 29	SW	4,649	295	29
July	54.0	81	102	[2] 7	59	1	SW	4,745	420	3
August	47.4	84	105	3	52	[2] 30	SW	4,680	262	5
September	61.8	66	99	[2] 1	35	19	SW	3,874	266	23
1919:										
April	68.1	57	88	22	31	9	SW	6,850	523	18
May	74.3	62	89	3	44	20	SE	4,531	307	2
June	71.5	71	90	30	44	1	SW	3,694	288	1
July	59.2	80	100	10	54	22	SW	5,090	321	11
August	62.7	83	104	14	61	31	SW	4,531	283	14
September	62.9	74	99	10	46	22	SW	5,332	337	3
1920:										
April	52.2	53	86	29	22	3	SW	8,047	608	11
May	66.3	66	92	[2] 25	43	[2] 14	ESE	5,681	341	10
June	57.9	77	104	30	53	[2] 4	SW	7,116	431	24
July	57.9	80	107	1	58	[2] 8	SE	4,565	361	12
August	66.6	74	96	30	52	13	SE	3,756	250	30
September	62.3	72	94	24	33	29	SE	4,728	342	14
1921:										
April	55.8	57	94	23	26	9	NW	6,559	440	3
May	55.3	69	96	[2] 27	36	2	SW	5,023	255	18
June	69.3	75	95	27	58	19	SE	3,910	284	15
July	60.8	81	101	18	63	9	SE	4,555	426	2
August	53.6	81	107	5	55	2	SE	4,351	255	9
September	56.8	76	98	2	40	29	SW	6,331	429	1

[1] The relative humidity was calculated from wet and dry bulb readings taken at 8 a. m., 1 p. m., and 5 p. m. each day.

[2] The same temperature occurred on other dates.

[3] Data taken from Climatological Data, Oklahoma Section, Annual Summary, 1915, from records of the United States Weather Bureau station at Woodward, Okla.

TEMPERATURE.

The daily range in temperature is wide. In summer the days are warm to hot, usually followed by cool nights. The data on mean, maximum, and minimum temperatures, by months, for the growing season (April to September) during the 8-year period from 1914 to 1921, inclusive, are given in Table 4.

The frost-free period is of considerable moment in experimental work when the time of seeding is a factor under observation. Data on the date of last killing frost in the spring and the first killing frost in the fall are available for 14 years at Woodward, and these dates, together with the length of the frost-free period, are shown graphically in Figure 3. A map of the southern Great Plains area is shown in Figure 4, on which the average annual precipitation and the length of the frost-free period are indicated.

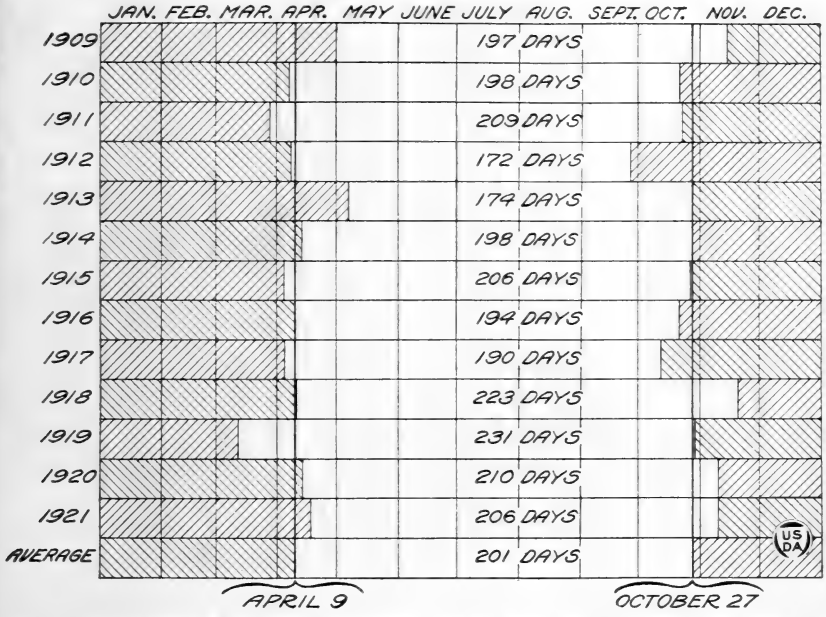

FIG. 3.—Diagram showing the annual and average frost free period for the 13 years from 1909 to 1921, inclusive, at Woodward, Okla. (Data from the records of the United States Weather Bureau.)

EVAPORATION.

The loss of moisture by evaporation in this region is great. The principal factors which influence evaporation are humidity, wind, temperature, and precipitation. Evaporation is naturally most rapid under conditions of low humidity, strong wind, high temperature, and low rainfall.

TABLE 5.—*Monthly, seasonal, and 8-year monthly average precipitation and evaporation at the Woodward Field Station, during the growing season (April to September), during the 8-year period from 1914 to 1921, inclusive.*

[Data (in inches) furnished by the Office of Biophysical Investigations, Bureau of Plant Industry.]

Year.	Apr.		May.		June.		July.		Aug.		Sept.		Total.		Ratio of E. to P.
	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	
1914	1.7	6.8	3.2	6.2	0.6	11.3	1.9	10.9	2.6	8.9	0.6	8.4	10.6	52.5	4.94
1915	6.5	6.0	5.3	6.7	2.4	6.6	3.1	10.0	3.6	6.5	5.7	5.8	26.6	41.6	1.56
1916	1.8	5.9	1.7	10.1	10.3	8.2	0	10.7	1.0	11.1	2.3	7.9	17.1	53.9	3.15
1917	1.6	6.8	1.0	7.0	1.4	11.5	1.1	11.7	6.7	7.6	2.7	5.3	14.5	49.9	3.44
1918	2.2	5.0	4.0	9.3	1.9	8.7	.7	10.1	1.4	11.0	1.2	5.8	11.4	49.9	4.38
1919	4.1	6.0	4.3	5.4	2.2	6.4	1.4	10.7	1.9	9.3	.6	7.6	14.5	45.4	3.13
1920	1.1	7.7	3.4	6.4	1.3	10.4	4.7	9.8	3.0	6.9	5.0	7.3	18.5	48.5	2.62
1921	1.8	6.9	1.9	8.0	5.8	7.3	2.5	9.3	5.1	10.3	2.9	8.8	20.0	50.6	2.53
Average	2.6	6.4	3.1	7.4	3.2	8.8	1.9	10.4	3.2	9.0	2.6	7.1	16.6	49.0	2.95

Table 5 shows a comparison of the monthly precipitation and evaporation as recorded at the Woodward Field Station during the six months from April to September, inclusive, for each year of the 8-year period from 1914 to 1921, inclusive. The evaporation measured is from a free water surface, the method being that employed by the Office of Biophysical Investigations of the Bureau of Plant Industry. During this period the evaporation has been about three times as great as the precipitation. July has the highest average evaporation and the lowest precipitation of the months considered in this 8-year period, the evaporation having been more than five times as great as the precipitation for this month. The average evaporation and precipitation for June and August are practically the same for this period.

CLASSIFICATION OF THE GRAIN SORGHUMS.[2]

The grain sorghums consist of several distinct groups of varieties, together with varieties which have doubtless originated by hybridization and are difficult to class definitely with any of the recognized groups. The different groups and varieties react differently to environmental conditions and naturally give different results under the varying climatic conditions of the southern Great Plains. To understand the results of the experiments reported herein, it is necessary to know the characters by which the groups and varieties differ. The relation of grain sorghums to other sorghums is first shown and a key to the groups of grain sorghums is then presented, indicating the characters by which the groups are distinguished.

The sorghums grown in this country may be divided into four general agronomic divisions, as follows:

(1) Grain sorghums, sorghums grown primarily for the feeding value of the grain, including such groups as kafir, durra and milo, and kaoliang.

(2) Sorgos, or forage sorghums, known also as sweet or saccharine sorghums, including such varieties as Amber, Orange, and Sumac.

(3) Broom corn, a specialized sorghum grown for the threshed panicle utilized for brooms.

(4) Grass sorghums, which include Johnson, Sudan, and Tunis grasses.

[2] Classification from Ball, C. R., and Rothgeb, B. E. Grain-sorghum experiments in the Panhandle of Texas. U. S. Dept. Agr. Bul. 698, 91 p., 13 fig. 1918.

This bulletin treats only of the grain sorghums. The groups of the grain-sorghum division may be separated by the following key:

Spikelets broadly obovate, one-sixth to one-fourth inch wide; seeds large, lenticular, flattened; panicle oval-ovate, short branched, compact ..... MILO-DURRA.
Spikelets oval or narrowly obovate, one-twelfth to one-sixth inch wide; seeds midsized to small, ovoid, scarcely flattened:
  Stems stout, somewhat juicy; internodes short; leaves 12 to 15, broad, usually dark green ..... KAFIR.
  Stems slender, dry; internodes longer; leaves 7 to 12, narrower and lighter green:
    Panicle compressed; glumes tightly appressed to the brown or white seeds ..... KAOLIANG.
    Panicle conical, loose; glumes spreading, exposing yellowish white seeds ..... SHALLU.

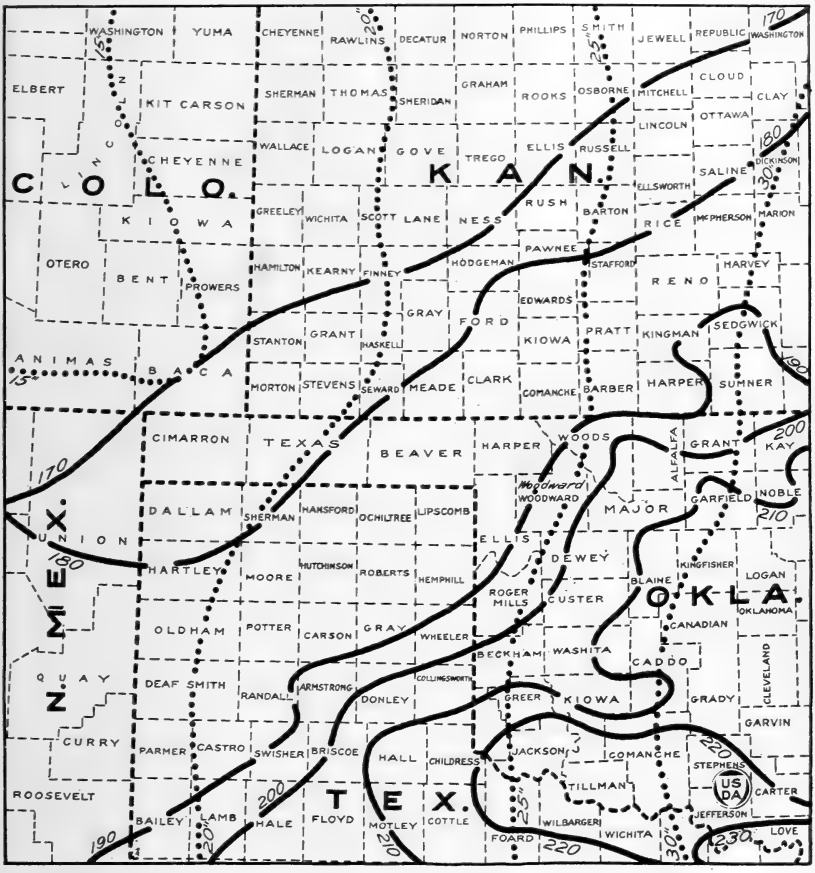

FIG. 4.—Map of the southern Great Plains, showing the average annual precipitation (dotted lines) and the number of days in the frost-free period (solid lines).

Each of the groups is described in the account of the varietal experiments, descriptions of the different varieties of each group also being given.

EXPERIMENTAL METHODS.

The main objects of the grain-sorghum experiments herein reported were to determine the relative value of different varieties, the best time to sow the crop, and the best stand or spacing between rows and between plants for grain production. These experiments were conducted in plats under conditions of good farm practice as to preparation of soil and cultivation.

SIZE AND ARRANGEMENT OF PLATS.

The land used in these experiments is divided into series, or blocks, which are 8 rods wide and extend the entire length of the field from north to south. The series are separated by roads 20 feet wide. The rows extend across the series from east to west and are spaced 44 inches apart. Thus, each row occupies an area 132 feet long and 44 inches wide, or one-ninetieth of an acre. There are no alleys between plats, so there is no border effect except at the ends of the rows. The plats vary from 6 to 12 rows, depending on the nature of the experiment and the land available. The row, one-ninetieth of an acre, is considered the unit. In sowing the plats, the rows are extended several feet into the road at each end. When the plants have attained a height of 2 to 3 feet the ends of the rows are trimmed to the proper limits. All the rows are harvested ordinarily, but when adjacent plats differ materially in habit of growth or maturity the border rows of each are discarded.

CROP ROTATION.

It has been impracticable to follow a definite crop rotation in these experiments because of lack of suitable land. The practice has been to use the land for experimental plats for two years, followed by one year of uniform cropping. The object of the uniform field crop every third year is to leave the plat land in as uniform a condition as possible. Until 1919 the uniform crop was cowpeas, but this crop was found to leave the soil so loose that it blew very readily, and during the last two years the crop has been milo.

METHOD OF SEEDING.

A 2-row corn drill fitted with sorghum plates was used for sowing the plats in these experiments. Seeding has always been done at a heavy rate to insure a stand even under unfavorable conditions. When the plants were from 4 to 10 inches high the plats were thinned by hand to the stands desired in the different experiments.

METHODS OF OBTAINING DATA.

The plant and stalk spaces and the occurrence of suckers and heads were obtained by actual counts of the plants, stalks, and heads in all the rows of each plat for which these data are given. The extent of suckering is indicated by the number of stalks per plant. The number of suckers per plant is obtained by dividing the number of stalks by the number of plants and subtracting 1 from this quotient. The percentage of headed stalks is the number of heads divided by the total number of stalks per unit. The percentage of erect heads in the milos is determined by dividing the number of erect heads by

the total number of heads produced, the quotient being multiplied by 100 to express the result as a percentage.

The total growing period as given in this bulletin is the number of days from seeding to maturity. The vegetative period is the time from seeding until the heads have appeared. The date of heading is figured as the average between the date of the first heading (when most of the heads are showing through the boot or when earlier heads are fully exserted) and the date of full heading (when the heads of the main stalks are fully exserted). The fruiting period is the time from the date of heading until the kernels are ripe. The height of the plants is the average of measurements taken at several points (usually 10) in the plats.

The plats are harvested with a corn binder, leaving a stubble about 6 inches high. The bundles are shocked on the plat and are left to cure for one or two months before threshing. When ready to thresh, the bundles are hauled to the scales and weighed. Before threshing, the heads are cut from the bundles by means of a large knife mounted on a frame. Threshing is done with a small separator. In threshing the sorghums, it was found necessary to remove all but one concave and slow down the cylinder to prevent too much cracking of the grain. The grain as it comes from the separator contains varying quantities of trash and is fanned before grain yields and bushel weights are determined. The yields are figured on the basis of 60 pounds to the bushel for the kafirs and 58 pounds for other varieties.

ENVIRONING CONDITIONS.

A brief summary of the seasonal conditions for each of the eight years 1914 to 1921, inclusive, is given to help interpret the results obtained in these experiments.

The 1914 season was unfavorable for high yields. A rain of 1.96 inches on May 1, together with 13 light showers distributed through the remainder of the month, brought the rainfall for May up to the average. The seed germinated and the crops started well in this month. June was unfavorable for crop growth, a rain of 0.61 inch on the 15th being the only precipitation in the month, which was marked also by high evaporation. On July 6 a good rain fell, followed by a dry period of about a month. The rainfall for August was below normal, and half of the rain came after the principal varieties were ripe. The rainfall for September was but 0.56 inch divided in six light showers. Yields of grain sorghums were low.

The season of 1915 was wet for the sorghum belt. The rainfall for the months from April to September, inclusive, was 26.8 inches, and this was well distributed. At no time in the growing season did the crops lack moisture, so that high yields of most of the grain sorghums resulted.

Conditions very unfavorable for high yields prevailed during the 1916 season. While the seasonal precipitation was slightly above normal, this was due entirely to heavy rains during one month, June. The rainfall for the other five of the growing months was below the average, no precipitation whatever occurring in July. The six weeks of drought following the rainy June was responsible for the low yields. Evaporation for the season was the highest on record at this station. The sorghums headed and fruited during the drought, and the rainfall of August was not enough to help production. The result was a

low yield of all grain sorghums, with the lowest yields of kafirs obtained during the 8-year period.

The seasonal distribution of rainfall in 1917 was very unfavorable for normal development of crops. The rainfall for April, May, June, and July was much below normal, while that of August was more than double that month's average. Evaporation for June and July was the highest recorded at this station for these two months. These conditions caused the sorghums to make a second growth in August and September, which prolonged the growing period until frost. Frost occurred two weeks earlier than the average date. In spite of poor distribution of moisture during the earlier part of the summer, average yields of grain were obtained from the milos, and high yields were obtained from the kafirs.

The season of 1918 was dry. The rainfall of each month from April to September was below the average, with the exception of May, which was slightly above the average. The rainfall in June, July, and August was not sufficient to produce crops, and hot winds in these months were very detrimental to plant growth. As a consequence, low yields of all grain sorghums and the lowest yields of the milos in the 8-year period were produced.

The 1919 season is an excellent example of a season with a comparatively low rainfall during the months of June, July, August, and September, distributed in such a manner as to maintain crop growth and return high yields of grain sorghums. The seasonal precipitation, April to September, was 2 inches below the 8-year average, yet high yields of practically all grain sorghums were obtained.

The seasonal precipitation of 1920 was 2 inches above the average and was fairly well distributed. One droughty period from July 10 to August 10, during which no effective rains occurred, cut the yields of milos that were heading at that time. The yields of grain sorghums in general were high, and 1920 was an excellent season in the sorghum belt.

The season of 1921 was very favorable for crop production. The seasonal precipitation was 3.5 inches above the average and was well distributed. Though the rainfall in April and May was below the average, that of the months of June, July, August, and September was above normal. There were droughty periods during the latter part of both July and August, but rains came before serious damage was done. The results were high yields of the important varieties of grain sorghum.

VARIETAL EXPERIMENTS.

The objects of the varietal experiments were to determine the adaptation and value of the different groups and of the more important varieties in each group. The varietal studies with grain sorghums were started in 1914, and the results for eight years are reported.

The varieties and strains with which the work was started were obtained from the Amarillo Cereal Field Station, Amarillo, Tex., and were those which experiments at that station had shown to be best adapted to the sorghum belt, varieties of all groups of grain sorghums being included. The policy since these experiments were begun has been to discard those varieties and strains which prove to be of no economic value for this district and to add any new or promising variety or strain about which information is desired. In certain

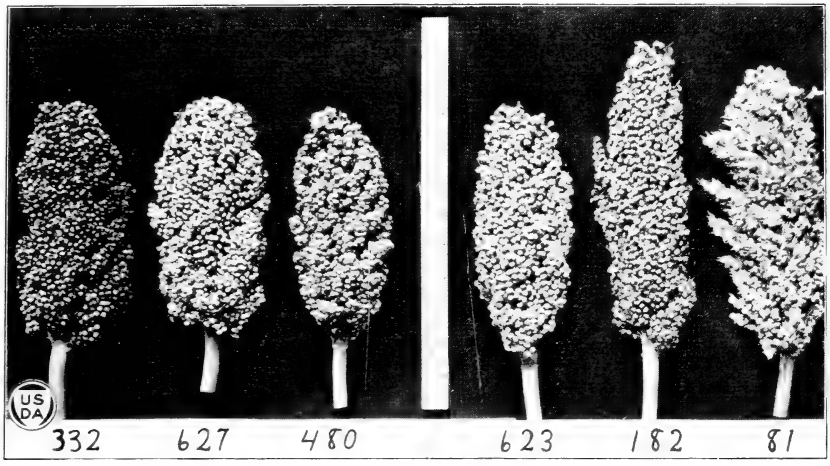

FIG. 1.—TYPICAL HEADS OF THE MILO-DURRA GROUP.

Sorghums grown in 1921 at the Woodward Field Station: No. 332, Dwarf Yellow milo; No. 627, Dwarf White milo; No. 480, Early White milo; No. 623, Spur feterita; No. 182, feterita; No. 81 White durra.

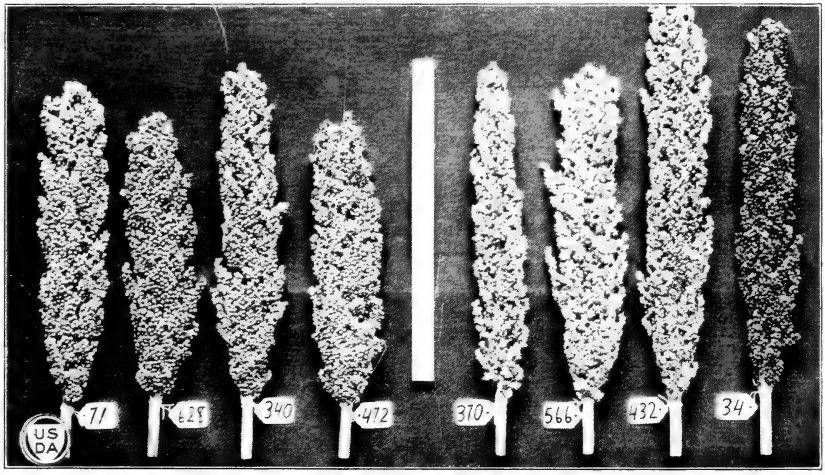

FIG. 2.—TYPICAL HEADS OF THE KAFIR GROUP.

Sorghums grown in the varietal plats at the Woodward Field Station in 1921: No. 71, Standard Blackhull kafir; No. 628, Reed kafir; No. 340, Dawn (dwarf) kafir; No. 472, Sunrise kafir; No. 370, White kafir; No. 566, White African kafir; No. 432, Pink kafir; No. 34, Red kafir.

FIG. 1.—A PLAT OF DWARF WHITE MILO (C. I. NO. 627).

This plat yielded 37.8 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

FIG. 2.—A PLAT OF BLACKHULL KAFIR (C. I. NO. 71).

This plat yielded 38.6 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

cases varieties of no economic value have been continued, because of a constant demand for information regarding them.

Results obtained from all selections, strains, and races of all the varieties under experiment in any or all of the eight years from 1914 to 1921, inclusive, are presented in the tables that follow. The importance of a full presentation of the climatic factors has already been indicated; it is even more necessary to give full agronomic data which show the reaction of the varieties to the varying environing conditions. The data in the tables, therefore, include not only yields but many other agronomic data which show conditions of the experiments as well as the response of the varieties. These data include the row space occupied by each plant and stalk, the length in days of the vegetative and fruiting periods and of the total growing period, the extent of suckering, the height of the plants, the percentage of stalks headed, the percentage of seed in the total crop, and (in the milos) the percentage of erect heads.

The date of seeding the varietal experiments has varied somewhat from year to year, the plan being to seed these experiments as near the middle of May as conditions permit. The dates of seeding these experiments in the several years are: 1914, May 11; 1915, May 26, reseeded on June 22; 1916, May 16 and 17; 1917, May 15; 1918, May 14; 1919, May 19; 1920, May 19; and 1921, May 17 and 18.

Each of the grain-sorghum groups is considered separately, a brief description of its distinguishing characters and a description of each variety included in these experiments being given.

THE MILO-DURRA GROUP.

The main characters which distinguish the milo-durra group from the other grain-sorghum groups are: Stems slender to midstout, dry and pithy, ripening with or before the seed; panicles short, broad, ovate or oval, short-branched, compact; seeds large. The varieties of this group represented in these experiments are milo, feterita, and White durra. Heads of several typical varieties of the milo-durra group are shown in Plate I, Figure 1.

THE MILOS.

Standard Yellow milo was the first milo introduced into the grain-sorghum belt. Later, a white-seeded variety appeared, which is the counterpart of the original milo except that the seed is white instead of orange yellow. A Dwarf Yellow milo has been in cultivation for about 15 years and has largely replaced the tall variety. The difference between the standard and dwarf milos is mainly in stature. At Woodward, Okla., the height of standard and dwarf milos has averaged in the ratio of 3 to 2. During recent years a dwarf white milo has made its appearance. As before stated, color of seed is the only apparent difference between the yellow and white varieties. The orange-yellow color of milo is not objectionable, as this color is not associated with a bitter or astringent flavor as is the brown color of certain kaoliangs and sorgos. On the other hand, the orange-yellow grain of milo frequently brings a premium on the market when it is to be used in mixed poultry feed.

At the beginning of these experiments three selections of Standard Yellow milo, one of Standard White milo, and three of Dwarf Yellow

milo were obtained from the Amarillo Cereal Field Station for trial. At the end of three years it was found advisable to discard two selections of Standard Yellow milo and one of the Dwarf milo. The remaining selections have been grown in the varietal experiments for the full 8-year period. As the varieties and races of milo respond to environing conditions in practically the same manner, the data for all milos are considered under one caption. The agronomic data for the different varieties of milo are given in Table 6. A plat of Dwarf White milo is shown in Plate II, Figure 1.

TABLE 6.—*Agronomic data for milo grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 58 pounds.]

Variety and year.	Row space.		Length of period.			Stalks per plant.	Erect heads.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.	
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.						Total crop.	Grain.
STANDARD YELLOW.												
C. I. No. 77:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bus.*
1914	15.1	7.7	72	30	102	1.97	97.8	64.5	4.8	15.5	5,100	790	13.6
1915	9.7	6.8	75	38	113	1.43	48.8	64.3	6.7	9.1	7,695	698	12.0
1916	7.0	6.3	72	40	112	1.11	98.3	58.9	4.0	23.3	3,200	745	12.8
Average	10.6	6.9	73	36	109	1.50	81.6	62.6	5.2	16.0	5,332	744	12.8
C. I. No. 223:													
1914	16.4	8.1	72	30	102	2.02	96.7	69.2	4.8	17.9	5,328	954	16.5
1915	9.2	6.8	75	38	113	1.35	43.1	66.5	6.7	8.9	8,460	756	13.0
1916	7.1	6.7	72	40	112	1.06	99.1	63.0	4.0	20.6	3,015	621	10.7
Average	10.9	7.2	73	36	109	1.48	79.6	66.2	5.2	15.8	5,601	777	13.4
C. I. No. 234:													
1914	9.1	6.8	72	30	102	1.29	98.1	76.2	4.8	38.2	2,790	1,067	18.2
1915	8.2	6.3	75	38	113	1.31	46.0	76.7	6.7	14.2	8,213	1,164	20.1
1916	7.4	7.2	72	40	112	1.03	99.5	70.1	4.0	20.8	3,555	738	12.7
1917	7.3	5.2	107	43	150	1.40	68.2	84.2	5.3	19.5	5,805	1,130	19.4
1918	7.3	5.9	78	31	109	1.25	97.6	21.6	3.5	6.3	2,205	140	2.4
1919	6.9	6.3	86	31	117	1.11	96.1	92.2	5.9	27.9	8,550	2,385	41.1
1920	8.1	6.2	90	37	127	1.30	89.8	91.4	4.9	21.8	7,678	1,697	29.3
1921	9.8	8.9	72	38	110	1.10	86.1	92.9	6.8	33.9	6,638	2,250	38.8
Average	8.0	6.6	82	36	118	1.22	85.2	75.7	5.2	22.8	5,679	1,321	22.8
STANDARD WHITE.													
C. I. No. 352:													
1914	8.0	6.9	75	30	105	1.17	98.3	53.4	5.0	10.9	4,428	482	8.3
1915	7.5	5.3	77	36	113	1.43	44.9	70.0	7.2	13.3	9,450	1,260	21.7
1916	7.5	7.2	74	40	114	1.03	99.8	54.2	4.3	13.4	2,610	351	6.1
1917	9.5	4.9	107	43	150	1.92	72.3	79.3	5.2	18.3	5,985	1,098	18.9
1918	7.6	5.8	78	31	109	1.32	97.9	17.3	3.5	5.8	2,250	131	2.3
1919	8.4	6.4	86	31	117	1.31	96.0	86.6	6.0	23.1	9,300	2,150	37.1
1920	7.9	5.8	90	37	127	1.37	87.4	90.3	4.8	21.0	7,971	1,671	28.8
1921	9.5	9.0	72	38	110	1.05	76.2	91.3	6.8	30.9	6,469	1,980	34.1
Average	8.2	6.4	82	36	118	1.33	84.1	67.8	5.4	17.1	6,058	1,140	19.7
EARLY WHITE.													
C. I. No. 480:													
1920	8.6	5.2	72	32	104	1.65	94.6	89.9	5.5	25.8	5,231	1,350	23.3
1921	7.5	6.7	67	27	94	1.12	61.7	94.6	6.8	38.0	5,006	1,901	32.8
DWARF YELLOW.													
C. I. No. 149:													
1914	9.0	6.3	72	31	103	1.43	98.2	76.9	3.8	21.1	3,753	792	13.7
1915	8.5	4.7	75	38	113	1.79	61.7	85.7	5.0	21.1	9,855	2,079	35.8
1916	6.1	5.6	72	40	112	1.09	99.8	55.5	3.0	24.2	2,475	599	10.3
Average	7.9	5.5	73	36	109	1.44	86.6	72.7	3.9	22.1	5,361	1,157	19.9

TABLE 6.—*Agronomic data for milo grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive*—Continued.

Variety and year.	Row space.		Length of period.			Stalks per plant.	Erect heads.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.						Total crop.	Grain.	
DWARF YELLOW—con.													
C. I. No. 332:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bus.*
1914	6.3	5.4	72	31	103	1.17	99.6	58.2	3.8	15.6	3,690	576	9.9
1915	7.3	4.3	75	38	113	1.70	69.1	82.8	5.0	21.1	10,260	2,169	37.4
1916	6.7	6.3	71	41	112	1.07	99.9	59.3	3.0	24.9	2,295	572	9.9
1917	7.7	4.5	107	43	150	1.73	53.9	85.2	3.0	19.7	4,650	915	15.8
1918	6.9	5.1	78	31	109	1.30	93.7	18.5	2.0	10.3	1,600	165	2.8
1919	6.2	5.6	86	31	117	1.10	99.5	83.5	3.7	30.5	4,905	1,494	25.8
1920	8.2	6.2	90	37	127	1.31	88.0	92.1	3.1	27.0	5,670	1,530	26.4
1921	8.4	6.8	72	38	110	1.24	84.6	95.2	4.9	37.7	6,390	2,412	41.6
Average	7.2	5.5	81	36	118	1.33	85.8	71.9	3.6	23.4	4,933	1,229	21.2
C. I. No. 359:													
1914	7.0	5.9	72	31	103	1.19	97.5	61.0	3.8	17.9	2,565	459	7.9
1915	8.6	4.5	75	38	113	1.93	50.1	84.7	5.0	21.8	10,294	2,245	38.7
1916	6.7	6.3	71	41	112	1.07	100.0	55.0	3.0	21.7	1,845	401	6.9
1917	7.4	4.4	107	43	150	1.66	65.8	87.6	3.0	24.4	4,275	1,044	18.0
1918	7.1	5.8	78	31	109	1.38	99.7	19.1	2.0	10.3	1,530	158	2.7
1919	6.9	5.6	86	31	117	1.23	99.0	84.8	3.7	30.0	6,480	1,944	33.5
1920	8.1	6.2	90	37	127	1.32	86.7	91.6	3.1	33.1	4,556	1,508	26.0
1921	8.7	6.6	73	37	110	1.32	78.2	94.5	4.9	37.0	6,356	2,351	40.5
Average	7.6	5.7	82	36	118	1.39	84.6	72.3	3.6	24.5	4,738	1,264	21.8
DWARF WHITE.													
C. I. No. 627:													
1920	12.8	8.3	90	37	127	1.55	85.1	96.5	3.2	30.1	5,850	1,661	28.6
1921	9.9	7.6	73	37	110	1.31	78.6	92.8	4.9	36.4	6,019	2,194	37.8

The vegetative period for the milos has varied from 72 days in the years 1914, 1916, and 1921 to 107 days in 1917, the average duration of the vegetative period being 82 days. The long vegetative period in 1917 was due to the drought of June and July, which occurred before the milos had headed, followed by late rains which caused second growth. The ripening period of milos has varied from 30 and 31 days in various years to 43 days in 1917, with an average of 36 days for the 8-year period. The length of the total growing period has been from 102 days in 1914 to 150 days in 1917, averaging 118 days for the 8 years. The variations in duration of vegetative, ripening, and total growing periods can be accounted for by a study of the climatic conditions, especially precipitation, obtaining during the growing seasons.

The average row space intended for each plant of milo in these experiments was about 7 inches. The variation from this spacing has been considerable at times, but the averages have not been far from the spacing desired. By a study of Table 6 it may be seen that the stands have been fairly comparable between varieties in any year; also between those of the different years.

The average stalk space has varied with the season and with the varieties, it being dependent on the plant space and extent of suckering. The average for the eight years has been 6.6 inches for the Standard Yellow milo, 6.4 inches for the Standard White milo, and 5.6 inches for the two selections of Dwarf Yellow milo. The extent of

suckering is indicated by the data in the column headed "Stalks per plant." The figures for the milos indicate that the dwarf milos sucker to a greater extent than the standard milos, also that the selection of Standard White milo produced more suckers than the selection of Standard Yellow milo, C. I. No. 234.

In height of plant there has been great variation, due to seasonal conditions, the Standard Yellow milo varying from 3.5 feet in 1918 to 6.8 feet in 1921, with an 8-year average of 5.2 feet. The average height of the Standard White milo has been 5.4 feet. The two selections of Dwarf Yellow milo have extremes of height of 2 and 5 feet in 1918 and 1915, respectively, and an average height of 3.6 feet for the eight years. The ratio in height between the standard and dwarf milos is close to 3 to 2.

The average of erect heads in the milos during the eight years is close to 85 per cent, the dwarf and standard varieties showing but little difference in this character. A low percentage of erect heads in milo is correlated with vigorous or rapid growth at the time of heading, hence the expression of this character is dependent on environing conditions before and during heading time.

The stalks headed fell below 22 per cent for all the milos in 1918, the year of poorest yields, and above 90 per cent in 1920 and 1921. The nearest approach to a correlation between the yield of grain and any other agronomic character is with the percentage of stalks headed. A correlation of this nature depends on the supposition that the row space per stalk is fairly constant for the plats compared.

The percentage of seed in the total crop has been slightly higher for the dwarf than for the tall varieties of milo. The average total crop weight for the eight years is highest for Standard White milo, with over 6,000 pounds per acre. The dwarf milos averaged less than 5,000 pounds per acre.

The average grain yield for the eight years was 22.8 bushels for the selection of Standard Yellow milo, 21.8 and 21.2 bushels for the two selections of Dwarf Yellow milo, and 19.7 bushels for the Standard White milo. The lowest yields for all milos were in 1918, less than 3 bushels per acre. The highest yields of the dwarf selections were obtained in 1921 and of the standard selections in 1919.

The only milo grown which varies in behavior from the foregoing varieties or selections is Early White milo (C. I. No. 480), which has been grown in these experiments for but two years. In these years it has matured in less time than the other varieties, both the vegetative and ripening periods being shorter than for the other varieties.

FETERITA.

Feterita [3] is a variety of the durra subgroup which has received much attention throughout the sorghum belt since the dry season of 1913. Under the conditions existing at Woodward, Okla., during the period of these experiments feterita has averaged in height the same as Standard Yellow milo. The stalk of feterita is more slender than milo under similar conditions, and the head, or panicle, which is always erect, is more elongated and less compact. The seeds are chalky white or bluish white, which color is associated with a brown

[3] Vinall, H. N., and Ball, C. R. Feterita, a new variety of sorghum. *In* U. S. Dept. Agr., Bur. Plant Indus. Circ. 122, p. 25–32. 1913.

inner coat. This seed color is similar to that of dwarf hegari and certain white-seeded kaoliangs, any of which when crossed with any ordinary white-seeded variety, as white-seeded kafirs, white milo, white durra, or shallu, gives a brown-seeded progeny in the F_1 generation. Feterita seeds are softer than those of milo and are more susceptible to decay in cool, damp soils.

One selection of feterita (C. I. No. 182) has been included in these experiments for the entire eight years. A second selection was grown for two years and discarded as of no greater value than C. I. No. 182. Spur feterita [4] was received in 1919 and has been included in the experiments since that date. The agronomic data and results obtained from feterita are presented in Table 7.

TABLE 7.—*Agronomic data for feterita and white durra grown at the Woodward Field Station during the eight-year period from 1914 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 58 lbs.]

Variety and year.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.	
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.
FETERITA.											
C. I. No. 182:	*Ins.*	*Ins.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
1914	14.0	7.2	63	39	102	1.96	89.6	4.8	46.0	1,251	576	9.9
1915	8.5	5.0	60	42	102	1.70	81.7	6.0	25.1	5,805	1,458	25.1
1916	9.0	8.3	60	39	99	1.09	73.9	4.8	28.8	1,530	441	7.6
1917	7.5	3.8	106	36	142	2.00	88.0	4.8	19.6	4,050	792	13.7
1918	6.9	5.0	63	24	87	1.36	64.9	3.5	20.5	1,800	369	6.4
1919	6.9	5.0	66	34	100	1.39	92.8	5.7	37.3	6,581	2,280	39.3
1920	7.3	4.2	68	35	103	1.75	94.2	5.0	28.8	5,906	1,699	29.3
1921	8.6	6.1	67	27	94	1.42	97.4	6.7	37.0	6,466	2,396	41.3
Average	8.6	5.6	69	35	104	1.58	85.3	5.2	30.4	4,174	1,251	21.6
C. I. No. 567:											
1915	8.3	6.5	64	43	107	1.27	88.9	6.5	26.5	5,231	1,384	23.9
1916	7.9	7.3	65	43	108	1.08	55.0	5.0	19.3	2,025	392	6.8
SPUR FETERITA.											
C. I. No. 623:											
1919	12.4	9.4	72	33	105	1.32	95.7	5.3	34.9	5,670	1,980	34.1
1920	8.1	6.0	72	39	111	1.36	91.3	4.6	24.7	7,136	1,633	28.2
1921	13.2	10.6	75	31	106	1.25	95.3	6.4	42.4	5,513	2,340	40.3
Average	11.2	8.7	73	34	107	1.31	94.1	5.4	34.0	6,106	1,984	34.2
WHITE DURRA.											
C. I. No. 81:											
1914	6.5	6.4	61	30	91	1.02	96.5	4.8	30.3	1,827	554	9.5
1915	9.0	6.6	60	40	100	1.35	79.1	6.2	29.1	4,770	1,386	23.9
1916	7.2	6.4	58	38	96	1.12	78.3	5.0	38.1	1,170	446	7.7
Average	7.6	6.5	60	36	96	1.16	84.6	5.3	32.5	2,589	795	13.7

The total length of growing period of feterita has varied from 87 days in 1918 to 142 days in 1917, the average for the 8 years being 104 days, as compared with 118 days for the milos. The vegetative period of feterita has been shorter than that of milo, averaging 69 days, as compared with 82 days for milo. The fruiting or ripening period has been of practically the same duration as for milo, 35 and 36 days, respectively.

[4] Conner, A. B., and Dickson, R. E. Spur feterita. Texas Agr. Expt. Sta. Bul. 275, 28 p., 14 fig. 1921.

The average row space per plant of feterita is greater than for milo. The feterita produced enough suckers to make the row space per stalk less than standard milo and identical with that of the dwarf milos. The total crop yield of feterita has been less than that for milo, but the grain yields have averaged practically the same. The percentage of seed in the total crop, therefore, is higher for feterita than for milo.

Spur feterita has been grown in these experiments for 3 years, 1919 to 1921, inclusive. During these 3 years it has had an average growing period of 107 days, made up of a vegetative period of 73 days and a ripening period of 34 days, as compared with 99 days total growing period, 67 days vegetative period, and 32 days ripening period for ordinary feterita. The Spur variety has averaged 21 fewer suckers to 100 plants than the C. I. No. 182, though the row space per plant was 3.6 inches greater for Spur than for the other variety.

In grain yields ordinary feterita has outyielded Spur in each of the three years, the averages being 36.6 and 34.2 bushels to the acre, respectively. In view of the variation in stands between the two varieties this difference of yield can not be regarded as significant.

WHITE DURRA.

One selection of White durra was grown in these experiments during the first three years, after which it was discarded because of its undesirable characters. The grain shatters easily, and the abundant pubescence and awns make the crop disagreeable to handle. The data on White durra for the three years are presented in Table 7.

TABLE 8.—*Yields of the varieties and races of the milo-durra group of grain sorghums grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

Variety and C. I. No.	Yields per acre (58-pound bushels).											
									Average.			
	1914	1915	1916	1917	1918	1919	1920	1921	3 years, 1914 to 1916.	2 years, 1920 and 1921.	3 years, 1919 to 1921.	8 years, 1914 to 1921.
Standard Yellow milo:												
No. 77	13.6	12.0	12.8	.....	.....	.....	.....	.....	12.8	.....	.....	.....
No. 223	16.5	13.0	10.7	.....	.....	.....	.....	.....	13.4	.....	.....	.....
No. 234	18.2	20.1	12.7	19.4	2.4	41.1	29.3	38.8	17.0	34.0	36.4	22.8
Standard White milo:												
No. 352	8.3	21.7	6.1	18.9	2.3	37.1	28.8	34.1	12.0	31.5	33.3	19.7
No. 480	.....	.....	.....	.....	.....	.....	23.3	32.8	.....	28.1	.....	.....
Dwarf Yellow milo:												
No. 139	13.7	35.8	10.3	.....	.....	.....	.....	.....	19.9	.....	.....	.....
No. 332	9.9	37.4	9.9	15.8	2.8	25.8	26.4	41.6	19.1	34.0	31.3	21.2
No. 359	7.9	38.7	6.9	18.0	2.7	33.5	26.0	40.5	17.8	33.3	33.3	21.8
Dwarf White milo:												
No. 627	.....	.....	.....	.....	.....	.....	28.6	37.8	.....	33.2	.....	.....
Feterita:												
No. 182	9.9	25.1	7.6	13.7	6.4	39.3	29.3	41.3	14.2	35.3	36.6	21.6
No. 567	.....	23.9	6.8	.....	.....	.....	.....	.....	.....	.....	.....	.....
No. 623	.....	.....	.....	.....	.....	34.1	28.2	40.3	.....	34.3	34.2	.....
White durra:												
No. 81	9.5	23.9	7.7	.....	.....	.....	.....	.....	13.7	.....	.....	.....

COMPARATIVE YIELD OF THE MILOS AND DURRAS.

Table 8 shows the annual and average yields of the varieties of the milo-durra group grown at Woodward, Okla., during the 8-year period under consideration. Several short-period averages are given, so that varieties which have been grown for less than eight years may be compared more readily with those for which the data for the full eight years are available. The five varieties grown in the eight years do not differ greatly in average yields, the variation between the two extremes, Standard Yellow milo and Standard White milo, being about 3 bushels.

THE KAFIR GROUP.

The kafir group as a whole possesses the following characters: Stems stout, semijuicy; leaves broad, dark green; panicles erect, cylindrical; lemmas not awned; seeds midsized to small. The varieties of kafir grown in these experiments are Blackhull, Dawn, Sunrise, Reed, White, Pink, and Red. Most of these varieties differ from the others by but few observable characters, and often these characters are those of seed color or glume color and are apparent to even the casual observer. Commercially the kafirs are of first importance among the grain sorghums in Kansas and central Oklahoma. Typical heads of the different varieties of kafir are shown in Plate I, Figure 2.

The agronomic data obtained from the kafir varieties are given in Table 9. In view of the differences between varieties and their reaction to environing conditions, each variety or subgroup of kafir is discussed separately.

BLACKHULL KAFIR.

Two selections of Blackhull kafir were originally included in the varietal experiments, but these proved to be practically identical, and after three years one was discarded. In 1917 another Blackhull kafir (C. I. No. 71) was obtained from the Amarillo Cereal Field Station and has been included in these experiments since then. During the fall of 1919 a distinct variety of Blackhull kafir was noticed at the local county fair, and a number of heads were obtained for seed. This kafir (C. I. No. 628) was placed in the varietal experiments the following season, and results are available for two years. This is a superior strain and in the two years has produced high grain yields. It has been named Reed kafir to distinguish it from other Blackhull strains. This kafir was originally selected and distributed by W. N. Reed, of Elk City, Okla.

Table 9 shows that on the average the vegetative period of C. I. No. 204 at Woodward has been 82 days, varying in the 8 years from 67 days in 1915 to 108 days in 1917. The short vegetative period in 1915 was caused by a late reseeding of the varieties, together with optimum growing conditions which caused rapid development. The long vegetative period of 1917 was due to dry weather during June and July, causing a suspension of growth, followed by a rainy August, with a resulting second growth. The fruiting period has averaged 37 days in duration, with a variation from 30 to 46 days. From Table 9 it may be noted that the Blackhull kafir (C. I. No. 71) requires a longer growing period than does C. I. No. 204, the total

growing period being from 1 to 2 weeks longer. A plat of C. I. No. 71 is shown in Plate II, Figure 2. The latest addition to the varietal experiments, Reed kafir (C. I. No. 628), seems to stand between the other two varieties in length of growing period, being nearer to C. I. No. 204 in this respect than to C. I. No. 71.

TABLE 9.—*Agronomic data for kafir varieties grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 60 pounds.]

Variety and year.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.	
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.
BLACKHULL.											
C. I. No. 207:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bus.*
1914	14.1	10.7	81	32	113	1.31	74.9	3.5	19.3	2,655	513	8.5
1915	12.7	8.4	71	42	113	1.51	61.4	5.7	21.8	6,570	1,431	23.8
1916	9.0	8.5	74	42	116	1.06	23.0	3.0	3.5	1,530	54	.9
Average	11.9	9.2	75	39	114	1.29	53.1	4.1	14.9	3,585	666	11.1
C. I. No. 204:												
1914	13.1	10.2	81	32	113	1.29	74.1	3.5	28.1	1,890	531	8.8
1915	10.0	6.6	67	46	113	1.51	79.3	5.5	20.8	6,525	1,359	22.6
1916	9.0	8.5	74	44	118	1.06	38.9	3.0	8.3	1,750	145	2.4
1917	11.5	5.7	108	42	150	2.01	76.3	5.0	22.9	5,850	1,341	22.3
1918	12.2	9.4	83	30	113	1.31	66.5	4.0	16.9	2,880	486	8.1
1919	12.4	9.0	81	32	113	1.37	73.7	4.0	25.5	4,950	1,260	21.0
1920	13.2	8.6	87	36	123	1.54	67.1	4.3	33.0	3,881	1,283	21.4
1921	12.0	10.3	71	34	105	1.17	90.2	4.7	38.8	4,243	1,646	27.4
Average	11.7	8.5	82	37	119	1.41	70.8	4.3	24.3	3,996	1,006	16.8
C. I. No. 71:												
1917	13.5	6.3	120	30	[1] 150	2.14	91.3	5.0	20.7	8,500	1,760	29.3
1918	12.1	10.6	88	39	127	1.14	26.2	3.5	4.5	2,750	125	2.1
1919	12.9	11.9	86	41	127	1.08	91.3	4.0	30.0	5,940	1,782	29.7
1920	12.1	11.2	93	42	135	1.08	90.7	4.5	34.9	6,043	2,108	35.1
1921	12.5	11.3	78	34	112	1.11	96.4	5.0	40.5	5,721	2,314	38.6
Average	12.6	10.3	93	37	130	1.31	79.2	4.4	26.1	5,791	1,618	27.0
C. I. No. 628:												
1920	12.5	11.0	85	40	125	1.14	95.4	5.0	35.1	6,493	2,276	37.9
1921	13.0	11.4	72	36	108	1.15	98.1	5.9	36.8	6,143	2,194	36.6
SUNRISE.												
C. I. No. 472:												
1914	13.1	10.4	71	36	107	1.27	85.1	4.5	38.3	1,620	621	10.3
1915	9.1	4.8	66	45	111	1.89	59.9	7.3	21.8	10,575	2,340	39.0
1916	8.9	7.8	73	44	117	1.15	71.1	5.0	10.4	3,550	370	6.2
1917	9.8	3.9	108	42	150	2.49	97.1	7.0	21.9	10,125	2,214	36.9
1918	12.0	7.9	79	34	113	1.52	68.1	5.0	17.1	3,375	576	9.6
1919	12.2	5.9	81	41	122	2.06	88.4	6.0	24.3	9,315	2,264	37.7
1920	12.8	6.9	85	38	123	1.85	95.4	6.1	27.0	7,875	2,126	35.4
1921	10.2	8.4	69	34	103	1.22	97.1	6.7	36.2	5,850	2,115	35.2
Average	11.0	7.0	79	39	118	1.68	82.8	6.0	24.6	6,536	1,578	26.3
DAWN.												
C. I. No. 340:												
1914	10.2	7.0	71	36	107	1.45	75.8	3.3	24.6	2,900	710	11.8
1915	9.6	5.7	70	41	111	1.68	54.9	5.2	24.9	9,315	2,322	38.7
1916	9.1	7.9	73	46	119	1.15	46.9	3.5	9.3	2,300	215	3.6
1917	10.3	4.3	108	42	150	2.41	96.5	4.8	23.7	8,505	2,016	33.6
1918	12.2	7.7	79	34	113	1.59	62.2	3.7	14.7	3,150	464	7.7
1919	12.1	6.8	81	41	122	1.77	86.8	4.0	26.2	6,975	1,827	30.4
1920	12.2	7.7	85	38	123	1.58	92.9	3.9	32.4	5,906	1,950	32.5
1921	11.7	10.8	69	34	103	1.08	97.3	4.4	39.5	4,838	1,913	31.9
Average	10.9	7.2	80	39	119	1.59	76.7	4.1	24.4	5,486	1,427	23.8

[1] In 1917 Blackhull kafir (C. I. No. 71) was about 50 per cent ripe when killed by frost on October 12.

FIG. 1.—A PLAT OF SUNRISE KAFIR.

This plat yielded 35.2 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

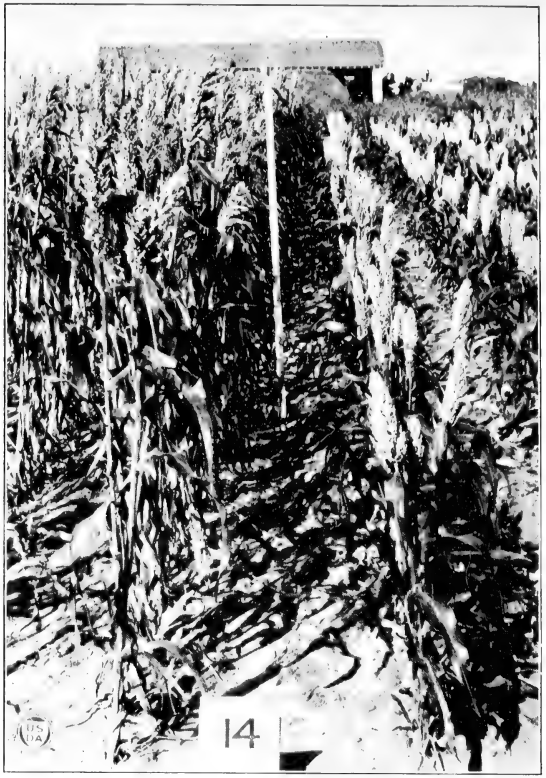

FIG. 2.—WHITE AFRICAN KAFIR (C. I. NO. 566).

The tall selection yielded 39.7 bushels per acre, and the dwarf selection yielded 33.5 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

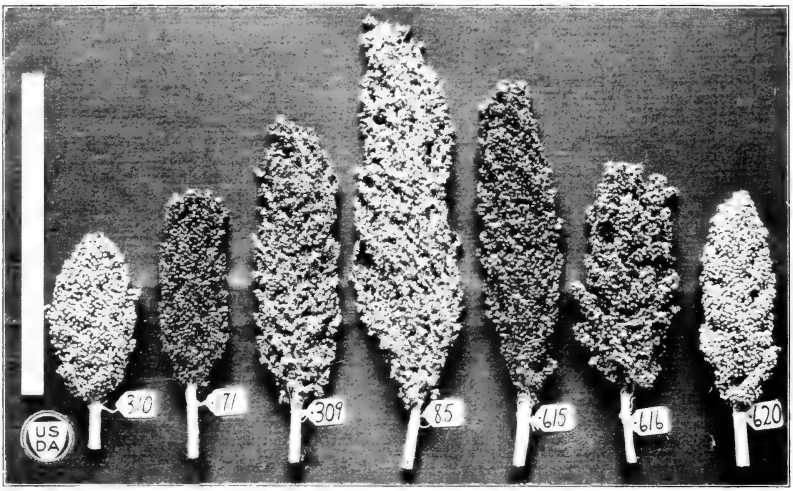

FIG. 1.—TYPICAL HEADS OF VARIOUS SORGHUMS.

Heads grown in 1921 in the varietal plats at the Woodward Field Station: No. 310, Blackhull kaoliang; No. 171, Manchu kaoliang; No. 309, Valley kaoliang; No. 85, shallu; No. 615, darso; No. 616, Schrock sorghum; No. 620, Dwarf hegari.

FIG. 2.—PLAT OF DWARF YELLOW MILO IN THE DATE-OF-SEEDING EXPERIMENTS.

This plat was sown on June 15 and yielded 49.6 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

TABLE 9.—*Agronomic data for kafir varieties grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive*—Continued.

Variety and year.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
WHITE.												
C. I. No. 370:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bus.*
1914	10.2	9.5	68	41	109	1.07	98.1	4.0	47.6	1,050	500	8.3
1915	9.5	7.1	71	42	113	1.35	71.8	5.3	26.3	5,715	1,503	25.1
1916	8.4	8.3	58	34	92	1.02	76.2	3.5	31.5	1,530	482	8.0
1917	12.1	6.7	104	46	150	1.80	95.8	4.5	29.5	5,400	1,593	26.6
1918	12.2	10.9	79	30	109	1.11	66.5	3.5	15.0	2,340	351	5.8
1919	12.7	11.6	81	32	113	1.10	91.6	3.7	26.7	4,590	1,224	20.4
1920	14.3	12.5	84	34	118	1.15	83.0	3.8	33.0	3,544	1,170	19.5
1921	11.3	10.8	63	36	99	1.05	98.6	4.4	47.1	3,317	1,564	26.1
Average	11.3	9.7	76	37	113	1.21	85.2	4.1	32.1	3,436	1,048	17.5
C. I. No. 566:[2]												
1914	18.7	14.3	81	32	113	1.31	81.8	5.0	15.1	2,385	360	6.0
1915	11.0	8.3	74	40	114	1.33	77.3	5.6	29.9	6,255	1,872	31.2
1916	8.8	8.7	77	57	134	1.02	36.8	4.0	4.6	2,835	131	2.2
1917	10.9	6.4	109	41	150	1.71	90.1	6.0	26.2	5,963	1,548	25.8
1918	12.8	10.5	85	33	118	1.22	56.0	4.1	13.8	2,925	374	6.2
1919	12.3	9.4	84	43	127	1.32	87.1	4.9	26.1	5,535	1,440	24.0
1920	13.2	10.0	85	45	130	1.32	85.2	4.8	34.9	4,687	1,627	27.1
1921	11.3	10.3	70	38	108	1.10	97.2	6.2	40.9	5,400	2,197	36.6
Average	12.4	9.7	83	41	124	1.29	76.4	5.1	23.9	4,498	1,194	19.9
C. I. No. 566, dwarf:												
1916	8.9	9.7	77	57	134	1.02	40.3	3.0	[3]	[3]	[3]	[3]
1917	10.5	6.6	109	41	150	1.60	89.6	4.0	27.8	5,175	1,440	24.0
1918	12.9	10.9	79	34	113	1.18	67.6	3.5	19.6	2,430	477	7.9
1919	12.4	10.1	82	45	127	1.23	89.1	3.8	23.2	5,040	1,134	18.9
1920	14.1	10.5	85	45	130	1.34	78.7	3.5	35.5	3,675	1,305	21.7
1921	11.4	10.7	68	38	106	1.07	97.0	4.4	47.9	4,200	2,010	33.5
Average	11.7	9.8	83	43	127	1.24	.....	3.7	.....	.....	.....	.....
C. I. No. 566, tall:												
1916	8.8	8.7	77	57	134	1.01	33.4	5.0	[3]	[3]	[3]	[3]
1917	11.2	6.2	109	41	150	1.82	90.6	8.0	24.5	6,750	1,656	27.6
1918	12.6	10.1	91	31	122	1.26	44.3	4.8	7.9	3,420	270	4.5
1919	12.2	8.7	85	42	127	1.40	85.1	6.0	29.0	6,030	1,746	29.1
1920	12.4	9.5	85	45	130	1.31	91.6	6.2	34.2	5,700	1,950	32.5
1921	11.1	9.9	72	38	110	1.12	97.4	8.1	33.9	6,600	2,385	39.7
Average	11.4	8.9	87	42	129	1.32	.....	6.4	.....	.....	.....	.....
RED.												
C. I. No. 212:												
1914	10.6	9.2	81	31	112	1.16	86.7	4.0	21.0	2,790	585	9.8
1915	10.7	7.6	74	39	113	1.41	93.8	6.0	25.5	8,235	2,097	34.9
1916	9.1	8.8	82	51	133	1.04	35.4	3.3	5.5	2,205	122	2.0
Average	10.1	8.5	79	40	119	1.20	72.0	4.4	17.3	4,410	935	15.6
C. I. No. 34:												
1914	8.9	8.0	81	31	112	1.12	86.9	4.0	18.4	2,745	504	8.4
1915	10.1	7.8	74	39	113	1.29	91.4	5.8	26.0	8,010	2,079	34.7
1916	8.8	8.7	82	51	133	1.01	46.2	3.3	6.8	2,565	176	2.9
1917	10.4	6.1	109	41	150	1.71	95.4	5.5	21.7	8,300	1,800	30.0
1918	14.4	12.1	85	36	121	1.19	70.8	4.0	15.7	2,800	440	7.3
1919	12.9	12.2	87	40	127	1.05	95.6	4.0	28.2	4,590	1,296	21.6
1920	12.9	11.9	90	44	134	1.09	90.5	4.2	32.6	4,838	1,575	26.3
1921	11.8	11.5	72	36	108	1.03	98.3	5.4	35.8	5,850	2,093	34.9
Average	11.3	9.8	85	40	125	1.19	84.4	4.5	23.2	4,962	1,245	20.8
PINK.												
C. I. No. 432:												
1921	11.1	10.8	68	31	99	1.03	98.3	5.7	47.7	4,556	1,871	31.2

[2] In 1916 and succeeding years data given for C. I. No. 566 are averages for dwarf and tall selections.
[3] In 1916 the yields of dwarf and tall selections of C. I. No. 566 were so poor that both lots were harvested together.

The stands obtained for the Blackhull kafirs have been rather uniform and permit comparisons between years and between different selections in any one year. The desired spacing for kafirs was 12 inches between plants in the row. As was the case with the milos, there appears to be no definite correlation between percentage of suckers and grain yield, the nearest to a correlation being between percentage of stalks headed and grain produced. The greatest degree of suckering was observed in 1917, when a second growth occurred. The average percentage of suckering for C. I. No. 204 was 40.7 for the eight years.

The average height of Blackhull kafir under Woodward conditions has been close to 4.5 feet, ranging from 3 to 5.5 feet for the varieties which have been grown for a period of years. Reed kafir (C. I. No. 628) in the two years it has been grown has been taller than either of the other two selections.

From a study of grain yields it is seen that in normal years C. I. No. 71 is superior in yielding capacity to C. I. No. 204. The latter selection is an inferior strain or has deteriorated in yielding ability, as an average of 16.8 bushels per acre is unsatisfactory for Blackhull kafir under these conditions.

SUNRISE KAFIR.

Sunrise, or Early Blackhull, kafir (C. I. No. 472) originated at the Amarillo Cereal Field Station from a single head selected in the autumn of 1906.[5] This kafir has been grown at the Woodward Field Station since these experiments were begun in 1914. Because of its adaptation to Woodward conditions Sunrise kafir has been recommended by this station for the production of both grain and forage in that part of the sorghum belt where conditions are similar to those at Woodward, Okla., or where a medium early maturing kafir taller than the dwarf (Dawn) kafir is desired. Sunrise kafir has proved so satisfactory at this station that it has been used to represent the kafir group in the cultural experiments and has been distributed to farmers. A plat of this kafir is shown in Plate III, Figure 1.

Sunrise kafir has been uniformly taller than any other selection of kafir grown in these experiments with the exception of a tall selection of an African kafir (C. I. No. 566). In earliness of maturing it has ranked second to White kafir (C. I. No. 370) and in some seasons has matured in as short a period as the White kafir. As grown at the Woodward station, Sunrise has shown better exsertion of head from the boot than any other kafir. The seed averages slightly smaller than that of ordinary Blackhull kafir. The complete experimental data recorded for Sunrise kafir are given in Table 9.

The row space per plant has varied from 13.1 inches in 1914 to 8.9 inches in 1916, the average for the eight years being one plant to each 11 inches of row space. Stalk space has varied from 10.4 inches in 1914 to 3.9 inches in 1917, the 8-year average being 7 inches. Sunrise kafir produces suckers freely, and its tendency in this regard is greater than that of any other kafir grown in these

[5] Ball, C. R., and Rothgeb, B. E. Grain-sorghum experiments in the Panhandle of Texas. U. S. Dept. Agr. Bul. 698, p. 58. 1918.

experiments. In two of the eight years, 1917 and 1919, Sunrise kafir produced more than one sucker per plant. The average for the eight years was 68 suckers per 100 plants.

The number of days in the vegetative period has varied from 66 days in 1915 to 108 days in 1917, the 8-year average being 79 days. The ripening period varied from 34 days in 1918 and 1921 to 45 days in 1915, the average for the eight years being 39 days. A long ripening period is caused by plenty of moisture after heading. The total growing period required to mature Sunrise kafir varied from 103 days in 1921 to 150 days in 1917, the 8-year average being 118 days.

The relation between percentage of stalks headed and grain yield in Sunrise kafir does not show the same correlation as in the milos. This indicates that while kafir usually produces a good percentage of headed stalks the yield of grain is dependent on the filling of the heads rather than on their number.

The height of the plants has varied from 4.5 feet in 1914 to 7.3 feet in 1915, the 8-year average being 6 feet. The height of Sunrise kafir makes it unsuitable to head by hand in the field, but it is well adapted to harvesting with a corn binder.

The grain yields for the eight years show but two kinds of years, good years when a yield of more than 30 bushels per acre was obtained and poor years when the yield was 10 bushels or less. On this basis there have been five good seasons and three poor seasons for Sunrise kafir during the 8-year period. The 8-year average yield of grain per acre was 26.3 bushels, which is higher than the average yield of any other variety of grain sorghum that has been grown during the entire 8-year period. The average total crop yield per acre indicates that Sunrise kafir also is a good variety for forage or silage production.

DAWN KAFIR.

Dawn, or Dwarf, kafir (C. I. No. 340) originated in 1906 from the same head selection as Sunrise. The chief differences between Dawn and Sunrise kafirs are that Sunrise is taller, the heads usually are better exserted, and the stalks also are juicier and sweeter. Dawn kafir has been grown alongside of Sunrise at Woodward since 1914. The experimental data for both varieties are shown in Table 9 to give an opportunity for easy comparison.

A study of Table 9 shows that the variation in space per plant has not been so great for Dawn as for Sunrise kafir, the variation in plant space of Dawn ranging from 12.2 inches to 9.1 inches, with an 8-year average of 10.9 inches, practically the same as for Sunrise. The row space per stalk has been slightly greater for Dawn than for Sunrise, the average for the eight years having been 7.2 inches. From a comparison of the row space of plants and stalks for these two varieties, it is readily seen that Sunrise has a tendency to produce more suckers than Dawn. In the 8-year period Dawn kafir produced 59 suckers per 100 plants.

In length of the vegetative, fruiting, and total growing periods Dawn and Sunrise kafirs have been practically identical. In only one year, 1916, was there any discernible difference between the two varieties, Dawn kafir then requiring two days more to mature than Sunrise.

The height of Dawn kafir has varied from 3.3 feet in 1914 to 5.2 feet in 1915, the average height for the eight years being 4.1 feet. The average height of Dawn kafir compared to the average height of Sunrise kafir gives a ratio of 1 to 1.44.

With the exception of 1914, Dawn kafir has been exceeded in both total crop and grain yield by Sunrise kafir. For the eight years, Dawn kafir has averaged 23.8 bushels per acre, or 2.5 bushels less grain and about 1,000 pounds per acre less total crop than Sunrise. Dawn kafir is well adapted to Woodward conditions as a grain crop to be grown for hand heading in the field, leaving the stalks in the field to hold the soil and prevent its blowing.

WHITE KAFIR.

White kafir is distinguished from Blackhull kafir in having glumes white or pale instead of black. Two strains of White kafir have been included in these experiments for the full 8-year period. C. I. No. 370 was received from the Amarillo Cereal Field Station, where it had been grown for a number of years, while C. I. No. 566, recorded as White African kafir, was received from D. P. Marum, of Woodward, Okla., who obtained it by direct importation from Africa. This latter lot was grown as a single strain in 1914 and 1915, but in 1915 it was observed that there were two distinct types of plants in the plat, tall and dwarf. Head selections were made from plants of each type and sown in separate plats in 1916. The tall and dwarf types came true, and the two types have since been grown in separate plats. The dwarf type is earlier than the tall, but has poor exsertion and does not yield as much grain as the tall selection. Plats of these two selections are shown in Plate III, Figure 2. The agronomic data obtained from the White kafirs are shown in Table 9.

The row space per plant for C. I. No. 370 has varied from 14.3 inches in 1920 to 8.4 inches in 1916, with an average of 11.3 inches for the eight years. The stalk space has averaged 9.7 inches for the eight years. Compared with the Blackhull, Sunrise, and Dawn kafirs, this selection of White kafir does not sucker extensively, the average for the 8-year period showing 21 suckers for each 100 plants. Considering an average of the two types of C. I. No. 566, the row space per plant was 18.7 inches in 1914 and 8.8 inches in 1916, the 8-year average being 12.4 inches of row space for each plant. The stalk space for the eight years has averaged 9.7 inches, the same as for C. I. No. 370. Suckering has been slightly greater for C. I. No. 566 than for the other White kafir, the average number of suckers being 29 per 100 plants.

The White kafir (C. I. No. 370) matures earlier than any of the other kafirs in the varietal experiment. The vegetative period has varied from 58 days in 1916 to 104 days in 1917, with an 8-year average of 76 days. The fruiting period has varied from 30 to 46 days in 1918 and 1917, respectively, with an average of 37 days. The average number of days in the total growing period is 113, or 5 days less than for Sunrise kafir. C. I. No. 566 is not as early as C. I. No. 370, the average total growing period for the two types of C. I. No. 566 being 124 days, or 11 days more than for C. I. No. 370.

In height of plants the White kafir (C. I. No. 370) has averaged the same as Dawn kafir. In the six years that the tall and dwarf types

of White African kafir (C. I. No. 566) have been grown separately there has been greater difference in height between them than between the Sunrise and Dawn kafirs. The ratio between the average heights of the dwarf and tall types of White kafir (C. I. No. 566) for six years is 1 to 1.73, while that between Dawn and Sunrise kafir for the same period is 1 to 1.47. The average height of the dwarf type was 3.7 feet, while the tall type averaged 6.4 feet for the six years.

In yield of grain, White kafir (C. I. No. 370) has been low. In 1916, however, its earliness enabled it to outyield Sunrise and Dawn kafirs by a narrow margin. For the 8-year period it has averaged 17.5 bushels per acre. The total crop weight has also been low. C. I. No. 566 has averaged practically 20 bushels of grain per acre for the eight years. The tall selection has shown some promise as a grain producer during the last few years. It is possible that further selection may result in a high-yielding kafir, though its height and relative lateness are against it.

RED KAFIR.

Red kafir can be readily distinguished from other members of the kafir group by the color of the seed, which is brownish red, and by its head being longer and more slender than those of other kafirs. The color of glumes of the Red kafir now grown in the varietal plat is very dark red. Red kafir is grown quite extensively in some communities of Oklahoma, where it is preferred to other varieties.

Two selections of Red kafir were included in these experiments during the first three years. As there was no apparent difference between the two selections, one was then discarded, while the other has been carried in the varietal plats for the full eight years. The experimental data for Red kafir are given in Table 9.

The stands obtained with Red kafir have been comparable with those of other kafirs. Red kafir has been less inclined to sucker than any other kafir grown at this station, the average number of suckers produced in the eight years having been 19 for every 100 plants.

In length of total growing period, Red kafir is comparable with the late-maturing Blackhull kafir (C. I. No. 71). During the last 5 years of these experiments, Red kafir has matured on the average in 128 days, while the Blackhull has required 130 days. In the full 8-year period Red kafir has averaged 7 days later in maturing than Sunrise kafir.

In height Red kafir has varied from 3.3 feet in 1916 to 5.8 feet in 1915, the average height being 4.5 feet. During the last five years it has averaged about 2 inches taller than Blackhull kafir (C. I. No. 71). Red kafir has made an average yield of 20.8 bushels of grain and practically 5,000 pounds of total crop per acre in the 8-year period. This is 3 bushels per acre less grain and 500 pounds less total crop than Dawn kafir.

PINK KAFIR.

Pink kafir (C. I. No. 432), which is grown extensively in the vicinity of Hays, Kans., has been included in these experiments for but one year, hence no comparisons of any value can be made at this time. The data for the one crop which has been grown are given in Table 9. The indications from the data for that year are that

this variety is early in maturing and that the yield of grain is high. Pink kafir has a white glume mixed with red, while the seed is white with red spots of varying size.

COMPARATIVE YIELDS OF THE KAFIR GROUP.

The annual and average acre yields of the selections of the kafir group grown in these experiments are given in Table 10. Six varieties of kafir have been grown for the full 8-year period, one strain each of Blackhull, Sunrise, Dawn, and Red, and two of White kafir.

For the 8-year period, Sunrise kafir leads in grain yield with an average of 26.3 bushels per acre, Dawn ranks second with 23.8 bushels per acre, and Red kafir is third with an average yield of 20.8 bushels.

Of the varieties and selections not grown for the entire 8-year period, several show high yielding power. Blackhull kafir (C. I. No. 71) in the five years it has been grown has yielded slightly less than Dawn during the same period and has averaged 3 bushels per acre more than Red kafir. Reed kafir (C. I. No. 628) has been grown for but two years, during which it has averaged more grain than any other kafir in the experiments. The tall type of White African kafir (C. I. No. 566) has made a very good showing during the years since it was separated from the dwarf type.

The yields obtained show that Sunrise and Dawn kafirs are well adapted for grain production under conditions at the Woodward Field Station.

TABLE 10.— *Yields of the varieties and races of the kafir group of grain sorghums grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

Variety and C. I. No.	Yields per acre (60-pound bushels).											
									Average.			
	1914	1915	1916	1917	1918	1919	1920	1921	3 years, 1914 to 1916.	2 years, 1920 and 1921.	5 years, 1917 to 1921.	8 years, 1914 to 1921.
Blackhull:												
No. 71	.....	.....	.....	29.3	2.1	29.7	35.1	38.6	.....	36.9	27.0	.....
No. 204	8.8	22.6	2.4	22.3	8.1	21.0	21.4	27.4	11.3	24.4	20.0	16.8
No. 207	8.5	23.8	.9	.....	.....	.....	.....	.....	11.1	.....	.....	.....
No. 628	.....	.....	.....	.....	.....	.....	37.9	36.6	.....	37.3	.....	.....
Dawn:												
No. 340	11.8	38.7	3.6	33.6	7.7	30.4	32.5	31.9	18.0	32.2	27.2	23.8
Sunrise:												
No. 472	10.3	39.0	6.2	36.9	9.6	37.7	35.4	35.2	18.5	35.3	31.0	26.3
White:												
No. 370	8.3	25.1	8.0	26.6	5.8	20.4	19.5	26.1	13.8	22.8	19.7	17.5
No. 566 average	6.0	31.2	2.2	25.8	6.2	24.0	27.1	36.6	13.1	31.9	23.9	19.9
No. 566 dwarf	.....	.....	.....	24.0	7.9	18.9	21.7	33.5	.....	27.6	21.2	.....
No. 566 tall	.....	.....	.....	27.6	4.5	29.1	32.5	39.7	.....	36.1	26.7	.....
Red:												
No. 34	8.4	34.7	2.9	30.0	7.3	21.6	26.3	34.9	15.3	30.6	24.0	20.8
No. 212	9.8	34.9	2.0	.....	.....	.....	.....	.....	15.6	.....	.....	.....

THE KAOLIANG GROUP.

The kaoliangs are grain-producing varieties of sorghum from eastern Asia. The group has been fully described by Dr. C. R. Ball.[6] Plate IV, Figure 1, shows heads of three varieties of kaoliang, together

[6] Ball, C. R. The kaoliangs: A new group of grain sorghums. U. S. Dept. Agr., Bur. Plant Indus. Bul. 253, 64 p., 15 fig., 2 pl. 1913.

with other varieties of sorghum. The varieties of kaoliang grown at the Woodward Field Station were selected as those showing most promise at the Amarillo Cereal Field Station. Seven varieties and strains were grown in the first year of these experiments, one white (Mukden), one blackhull white, and five brown (two of Manchu and one each of Parker, Valley, and Shantung Dwarf). After the first year one of the brown kaoliangs (Parker) was discarded, and at the end of three years the white (Mukden) and two of the brown strains (Shantung Dwarf and Manchu, C. I. No. 328) were dropped. One blackhull and two brown kaoliangs have been grown during the full 8-year period. The data for the varieties of kaoliang grown during the eight years are presented in Table 11.

The Blackhull kaoliang grown at the Woodward Field Station at present differs in a number of characters from the original Barchet Blackhull. This change in varietal character was caused by field hybridization, possibly with feterita. In 1915 the heads of this strain that had been saved for seed were all used in the first seeding. As reseeding was necessary, a supply of bulk seed was obtained from the Amarillo Cereal Field Station. The plat produced from this seed varied greatly in color and type. A number of white-seeded heads were selected from this plat for use the following season, but the plat produced from them had a high percentage of brown-seeded plants. White-seeded heads were again selected for seed in the fall of 1916. In 1917 the plat consisted of 10 head rows. The plants were uniformly white seeded, but each row was of a different type. Since 1917 the types have bred true, and in 1919 and 1920 a small-seeded, compact-headed type was found to be the best yielder. Though the other types have been grown in single rows, the progeny of row 1 in 1917 is the type now included in these experiments as Blackhull kaoliang.

Table 11 shows that the row space for the plants of kaoliang has been less than that for other groups. The stands from year to year, however, have not been uniform. The desired space between kaoliang plants under Woodward conditions is about 5 inches. The row space per plant for Blackhull has varied from 4.8 to 11.8 inches, with an average of 7.5 inches. Manchu (C. I. No. 171) and Valley (C. I. No. 309) kaoliangs have averaged 6.4 and 5.9 inches of row space per plant, respectively. It is to be noted that the kaoliangs are less inclined to produce suckers than any of the other grain sorghums. Blackhull, which has produced as many suckers as any of the varieties of kaoliang, due largely to thin stands in several years, produced an average of only 14 suckers for every 100 plants.

The kaoliangs are early in maturing, especially the brown varieties. Manchu (C. I. No. 171) has matured grain on the average in 101 days during the 8 years of these experiments. Valley (C. I. No. 309) has required an average of 4 days longer in which to mature. Blackhull has matured on the average in 111 days, which is longer by 7 days than the total growing period of feterita.

In height the three kaoliangs grown for the full 8-year period have averaged from 5.3 to 5.7 feet. One of the kaoliangs, Shantung Dwarf (C. I. No. 293), which was grown for but three years, is very dwarf, averaging only 3.1 feet in height. This selection is at present grown in single rows, in order to have it available for breeding work as a source of dwarf stature.

TABLE 11.—*Agronomic data for the kaoliangs grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

[In the statement of yields of grain the bushel is rated at 58 pounds.]

Variety and year.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
Mukden (C. I. No. 190):	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
1914	5.7	5.5	65	26	91	1.03	93.0	5.8	29.0	2,225	653	11.3
1915	7.4	5.7	64	43	106	1.30	92.1	8.0	26.8	6,390	1,710	29.4
1916	6.7	6.6	65	43	108	1.02	81.1	7.0	25.0	2,520	630	10.8
Average	6.6	5.9	65	37	102	1.12	88.7	6.9	26.9	3,712	998	17.2
Blackhull:												
1914	5.3	5.1	68	28	96	1.03	94.1	4.8	35.8	2,025	725	12.5
1915	5.6	5.0	68	38	106	1.10	94.1	6.7	31.8	5,805	1,845	31.8
1916	6.4	6.3	64	44	108	1.11	85.9	5.5	27.7	3,195	887	15.3
1917	4.8	4.0	108	34	142	1.19	87.6	5.3	22.1	4,815	1,062	18.3
1918	5.0	4.5	68	19	87	1.11	79.2	5.0	24.0	2,600	625	10.8
1919	11.2	9.2	77	36	113	1.22	94.6	4.6	30.7	3,870	1,188	20.4
1920	9.8	7.9	72	46	118	1.23	93.7	4.9	27.7	4,106	1,136	19.6
1921	11.8	10.3	79	38	117	1.16	94.5	5.8	35.6	3,375	1,200	20.7
Average	7.5	6.5	76	35	111	1.14	90.5	5.3	29.4	3,724	1,084	18.7
Manchu (C. I. No. 171):												
1914	8.6	8.5	63	26	89	1.01	93.9	5.0	61.5	1,134	698	12.0
1915	6.5	5.7	58	42	100	1.15	91.0	6.0	33.8	5,220	1,764	30.4
1916	6.0	5.8	58	31	89	1.03	88.0	5.8	36.6	2,115	774	13.3
1917	4.8	.....	105	34	139	.....	.....	5.0	6.4	2,610	167	2.9
1918	4.9	4.9	60	26	86	1.00	82.4	4.5	29.3	1,980	581	10.0
1919	6.5	6.3	71	29	100	1.04	84.7	5.8	31.4	2,925	918	15.8
1920	9.2	8.6	70	42	112	1.03	89.7	5.6	26.2	2,893	759	13.1
1921	4.6	4.7	70	27	97	.99	93.3	6.0	22.9	2,363	540	9.3
Average	6.4	.....	69	32	101	.....	.....	5.5	31.0	2,655	775	13.4
Valley (C. I. No. 309):												
1914	5.0	4.8	66	30	96	1.04	92.8	4.7	30.1	1,809	545	9.4
1915	5.9	4.8	64	39	103	1.22	82.9	7.0	36.1	5,535	1,998	34.5
1916	5.7	5.5	63	37	100	1.04	83.7	6.0	36.1	2,655	958	16.5
1917	4.4	.....	108	34	142	.....	.....	5.5	8.1	2,430	198	3.4
1918	4.4	4.2	60	27	87	1.04	80.0	5.0	29.7	1,950	580	10.0
1919	8.5	8.0	71	29	100	1.07	86.1	5.5	32.8	2,813	923	15.9
1920	7.8	6.9	70	44	114	1.14	92.5	5.7	37.1	4,050	1,504	25.9
1921	5.4	5.2	71	27	98	1.03	94.4	6.0	29.0	2,250	653	11.2
Average	5.9	.....	72	33	105	.....	.....	5.7	29.9	2,937	920	15.9
Manchu (C. I. No. 328):												
1914	5.1	5.0	51	27	78	1.02	97.7	4.5	20.3	1,593	324	5.6
1915	6.1	6.0	53	33	86	1.02	91.7	6.2	37.8	3,330	1,260	21.7
1916	5.5	5.5	51	31	82	1.00	85.5	5.5	25.4	1,850	470	8.1
Average	5.6	5.5	52	30	82	1.01	91.6	5.4	27.8	2,258	685	11.8
Shantung Dwarf (C. I. No. 293):												
1914	5.3	5.2	68	24	92	1.02	88.2	2.8	26.7	1,179	315	5.4
1915	7.4	6.7	64	36	100	1.10	94.8	3.8	42.2	3,690	1,557	26.8
1916	6.4	6.4	61	29	90	.99	70.1	2.7	34.1	1,450	495	8.5
Average	6.4	6.1	64	30	94	1.04	84.4	3.1	34.3	2,106	789	13.6
Parker (C. I. No. 424):												
1914	4.0	3.9	63	26	89	1.03	94.6	4.3	25.2	1,818	459	7.9

The grain yields of the kaoliangs have been low when compared with the other groups. Of the three varieties grown during the 8-year period, the Blackhull kaoliang has averaged highest, 18.7 bushels per acre. It is noteworthy that this is the only grain sorghum that has never fallen below 10 bushels per acre in any year, although its yield

has never been very high. Valley kaoliang has averaged 15.9 bushels per acre, while the Manchu averaged but 13.4 bushels. The total crop yields have been in proportion to the grain yields.

The annual and average acre yields of the kaoliangs are shown in Table 12, together with those of shallu and certain miscellaneous sorghums.

TABLE 12.— *Yields of the varieties and races of the kaoliang and shallu groups, and other miscellaneous grain sorghums grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

Variety and C. I. No.	Yields per acre (58-pound bushels).											
									Average.			
	1914	1915	1916	1917	1918	1919	1920	1921	3 years, 1914 to 1916.	4 years, 1918 to 1921.	5 years, 1917 to 1921.	8 years, 1914 to 1921.
White kaoliang:												
No. 190	11.3	29.4	10.8	.....	.....	.....	.....	.....	17.2	.....	.....	.....
Blackhull kaoliang:												
No number	12.5	31.8	15.3	18.3	10.8	20.4	19.6	20.7	19.9	17.9	18.0	18.7
Brown kaoliang:												
No. 171	12.0	30.4	13.3	2.9	10.0	15.8	13.1	9.3	18.6	12.1	10.2	13.4
No. 328	5.6	21.7	8.1	.....	.....	.....	.....	.....	11.8	.....	.....	.....
No. 293	5.4	26.8	8.5	.....	.....	.....	.....	.....	13.6	.....	.....	.....
No. 309	9.4	34.5	16.5	3.4	10.0	15.9	25.9	11.2	20.1	15.8	13.3	15.9
No. 424	7.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Shallu:												
No. 85	6.1	23.2	4.4	22.8	.3	19.4	18.2	28.7	11.2	16.7	17.9	15.4
Darso:												
No. 615	.....	.....	.....	25.7	5.2	27.1	24.8	22.7	.....	20.0	21.1	.....
Schrock sorghum:												
No. 616	.....	.....	.....	29.3	2.6	20.2	28.9	24.8	.....	19.1	21.2	.....
Dwarf hegari:												
No. 620	.....	.....	.....	.....	2.2	24.7	22.7	11.1	.....	15.2	.....	.....

THE SHALLU GROUP.

One selection of shallu has been included in these experiments for the full 8-year period. Shallu has been retained in the varietal experiments, as it is frequently exploited [7] under a variety of names, and reliable data are desirable. It has proved to be of little value under the conditions at the Woodward Field Station. The data for shallu are presented in Table 13, and a head of this sorghum is shown in Plate IV, Figure 1.

In grain yields shallu has varied from 0.3 bushel in 1918 to 28.7 bushels in 1921, with an average yield of 15.4 bushels to the acre, as compared with 26.3 bushels for Sunrise kafir and 21.8 bushels for Dwarf Yellow milo. The stalks are dry and pithy and practically valueless as forage.

MISCELLANEOUS SORGHUMS.

Three sorghums which do not belong to any of the main groups of grain sorghums were included in the experiments. These are darso [8] (C. I. No. 615), Schrock sorghum [9] (C. I. No. 616), and Dwarf hegari [9] (C. I. No. 620). Darso and Schrock sorghums, both of

[7] Ball, C. R. Three much-misrepresented sorghums. U. S. Dept. Agr., Bur. Plant Indus. Circ. 50, 14 p., 2 fig. 1910.
Rothgeb, B. E. Shallu, or "Egyptian wheat": A late-maturing variety of sorghum. U. S. Dept. Agr., Farmers' Bul. 827, 8 p., 2 fig. 1917. Rev. ed., 1921.

[8] Beeson, M. A., and Daane, Adrian. Darso. Okla. Agr. Exp. Sta. Bul. 127, 19 p., 6 fig. 1919.

[9] Vinall, H. N., and Edwards, R. W. New sorghum varieties for the central and southern Great Plains. U. S. Dept. Agr. Bul. 383, p. 16, 7 fig. 1916.

which originated in Oklahoma, probably resulted from chance hybridization between a sorgo and one of the kafirs. Dwarf hegari was obtained as an importation from the Sudan region of Africa, evidently from the same region from which feterita was obtained. Darso and Schrock appear to resemble the kafir group more than any other group of grain sorghums. However, darso has awned lemmas and its seed color is a dull reddish brown, different from any of the kafirs. Schrock sorghum, sometimes called Schrock kafir, is awnless, but its seed color is a yellowish brown, and the seeds have a very astringent flavor, thus differing from the kafirs. Dwarf hegari resembles feterita in the color of seed, but the seeds are much smaller than those of the milo-durra group. Since these three varieties differ in certain characters from the groups which they resemble most closely, they are considered separately. The experimental data obtained for these three sorghums are presented in Table 13, and typical heads are shown in Plate IV, Figure 1.

TABLE 13.—*Agronomic data for miscellaneous grain sorghums grown at the Woodward Field Station during the 8-year period from 1914 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 58 pounds.]

Variety and year.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
Shallu (C. I. No. 85):	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bus.*
1914	5.4	4.1	95	18	113	1.31	.....	.....	7.7	4,572	351	6.1
1915	.....	.....	80	.....	.....	.....	.....	.....	21.3	6,345	1,350	23.2
1916	6.7	5.3	91	43	134	1.26	51.3	5.0	7.2	3,555	257	4.4
1917	8.1	2.6	116	34	150	3.13	.....	6.5	21.5	6,165	1,323	22.8
1918	6.5	3.4	93	41	134	1.93	.9	4.0	.7	2,835	20	.3
1919	21.1	12.9	104	24	128	1.64	90.7	5.5	32.5	3,465	1,125	19.4
1920	9.8	7.5	102	52	154	1.30	85.6	6.3	27.7	3,825	1,058	18.2
1921	8.3	7.4	86	35	121	1.12	95.8	6.4	36.5	4,556	1,665	28.7
Average	.....	.....	96	.....	.....	.....	.....	.....	19.4	4,415	894	15.4
Darso (C. I. No. 615):												
1917	6.8	4.8	97	53	150	1.41	.....	4.5	25.4	5,950	1,490	25.7
1918	7.0	6.4	79	30	109	1.09	54.4	3.3	16.3	1,845	302	5.2
1919	6.3	6.1	88	37	125	1.03	83.2	3.7	33.0	4,770	1,575	27.1
1920	7.3	6.7	98	54	152	1.10	76.6	4.5	28.8	5,006	1,440	24.8
1921	6.6	6.7	83	38	121	.98	95.8	4.1	33.0	3,994	1,316	22.7
Average	6.8	6.1	89	42	131	1.12	.....	4.0	27.3	4,313	1,225	21.1
Schrock sorghum (C. I. No. 616):												
1917	9.1	4.6	110	[1] 40	150	1.97	90.2	4.5	23.0	7,400	1,700	29.3
1918	6.6	5.7	78	56	134	1.16	30.3	2.8	5.4	2,745	149	2.6
1919	9.6	9.2	91	37	128	1.05	87.5	3.5	27.1	4,320	1,170	20.2
1920	6.9	6.2	105	49	154	1.12	81.7	4.2	28.1	5,963	1,676	28.9
1921	6.8	6.9	83	38	121	.98	94.3	4.0	30.5	4,725	1,440	24.8
Average	7.8	6.5	93	44	137	1.26	76.8	3.8	22.8	5,031	1,227	21.2
Dwarf hegari (C. I. No. 620):												
1918	21.0	6.3	86	48	134	3.37	22.7	3.3	2.4	5,300	125	2.2
1919	9.4	7.5	88	40	128	1.24	85.5	3.5	27.2	5,265	1,431	24.7
1920	10.3	8.2	88	29	117	1.25	95.3	3.6	23.4	5,625	1,316	22.7
1921	12.8	11.3	75	45	120	1.14	79.8	4.2	30.0	2,138	641	11.1
Average	13.4	8.3	84	41	125	1.75	70.8	3.7	20.8	4,582	878	15.2

[1] Schrock sorghum (C. I. No. 616) was 60 per cent ripe at the first frost on Oct. 12.

The stands of both darso and Schrock sorghum have been uniform from year to year. Darso has averaged one plant every 6.8 inches of row space and Schrock one plant each 7.8 inches for the five years they have been included in these experiments. Neither of these two varieties is inclined to produce many suckers when grown with a row space of about 7 inches between plants. Darso has produced an average of 12.1 suckers for every 100 plants, while Schrock has averaged 25.4 suckers per 100 plants. This difference in suckering may be attributed to difference in stands between the two varieties. Poor stands of Dwarf hegari have been obtained in three of the four years, the row space per plant averaging 13.4 inches. With such thin stands many suckers have been produced, the variety averaging 75 suckers for each 100 plants.

From the data obtained none of the three varieties seem to be any earlier in maturing than the late selection of Blackhull kafir (C. I. No. 71). All three of these sorghums are rather dwarf.

The grain yields, which are for but five and four years, do not show any superiority when compared with the better varieties of kafir, and in 1918 all of these newer varieties made poor yields in common with most of the sorghums. One difficulty experienced with Dwarf hegari in 1921 was that it broke up, producing about 50 per cent tall plants. These were very late in maturing and were cut out or rogued before harvesting the plat. Whether this breaking up was due to chance crossing with other varieties or to an inherent unstable condition can not be stated. However, the same precautions were taken as with the other varieties to keep the seed of Dwarf hegari pure, and this was the only variety that behaved in this manner.

The annual and average yields of these three sorghums are shown in Table 12, with the kaoliangs and shallu.

COMPARATIVE YIELDS OF THE GRAIN SORGHUMS.

The annual and average yields of the varieties and selections of grain sorghum grown in the varietal experiments at the Woodward Field Station during all of the eight years from 1914 to 1921, inclusive, are shown in Table 14, together with those of other varieties which have been added to the experiment since 1914 and are still included. Averages for different periods of years are shown, in order to compare varieties and selections not grown for the full 8-year period. Four strains of milo, one of feterita, six of kafir, three of kaoliang, and one of shallu have been grown in the varietal experiments for the entire eight years.

Considering the average grain yields for eight years, Sunrise and Dawn kafirs rank first and second, respectively. Standard Yellow milo, the two dwarf milos, and feterita averaged practically the same, ranking after Sunrise and Dawn kafirs. Red kafir averaged slightly less, and the two brown kaoliangs and shallu made the lowest average yields in the 8-year period.

TABLE 14.—*Annual and average acre yields of the varieties and selections of grain sorghums grown at the Woodward Field Station, during the 8 years from 1914 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 60 pounds for the kafirs and at 58 pounds for all other sorghums.]

Group and variety.	C. I. No.	Yields per acre (bushels).										
		1914	1915	1916	1917	1918	1919	1920	1921	Average. 5 years, 1917 to 1921.	Average. 2 years, 1920 and 1921.	Average. 8 years, 1914 to 1921.
Milo-durra:												
Standard Yellow milo	234	18.2	20.1	12.7	19.4	2.4	41.1	29.3	38.8	26.2	34.1	**22.8**
Standard White milo	352	8.3	21.7	6.1	18.9	2.3	37.1	28.8	34.1	24.2	31.5	**19.7**
	480							23.3	32.8		28.1	
Dwarf Yellow milo	332	9.9	37.4	9.9	15.8	2.8	25.8	26.4	41.6	22.5	34.0	**21.2**
	359	7.9	38.7	6.9	18.0	2.7	33.5	26.0	40.5	24.1	33.3	**21.8**
Dwarf White milo	627							28.6	37.8		33.2	
Feterita	182	9.9	25.1	7.6	13.7	6.4	39.3	29.3	41.3	26.0	35.3	**21.6**
Spur feterita	623						34.1	28.2	40.3		34.3	
Kafir:												
Blackhull	71				29.3	2.1	29.7	35.1	38.6	27.0	36.9	
	204	8.8	22.6	2.4	22.3	8.1	21.0	21.4	27.4	20.0	24.4	**16.8**
Reed	628							37.9	36.6		37.3	
Dawn (dwarf)	340	11.8	38.7	3.6	33.6	7.7	30.4	32.5	31.9	27.2	32.2	**23.8**
Sunrise	472	10.3	39.0	6.2	36.9	9.6	37.7	35.4	35.2	31.0	35.3	**26.3**
White	370	8.3	25.1	8.0	25.6	5.8	20.4	19.5	26.1	19.7	22.8	**17.5**
White (average)	566	6.0	31.2	2.2	25.8	6.2	24.0	27.1	36.6	23.9	31.9	**19.9**
White (dwarf)	566				24.0	7.9	18.9	21.7	33.5	21.2	27.6	
White (tall)	566				27.6	4.5	29.1	32.5	39.7	26.7	36.1	
Red	34	8.4	34.7	2.9	30.0	7.3	21.6	25.3	34.9	24.0	30.6	**20.8**
Pink	432								36.2			
Kaoliang:												
Blackhull	310	12.5	31.8	15.3	18.3	10.8	20.4	19.6	20.7	18.0	20.2	**18.7**
Manchu	171	12.0	30.4	13.3	2.9	10.0	15.8	13.1	9.3	10.2	11.2	**13.4**
Valley	309	9.4	34.5	16.5	3.4	10.0	15.9	25.9	11.2	13.3	18.6	**15.9**
Miscellaneous:												
Shallu	85	6.1	23.2	4.4	22.8	.3	19.4	18.2	28.7	17.9	23.5	**15.4**
Darso	615				25.7	5.2	27.1	24.8	22.7	21.1	23.8	
Schrock	616				23.3	2.6	23.2	28.9	24.8	21.2	26.9	
Dwarf hegari	620					2.2	24.7	22.7	11.1		16.9	

DATE-OF-SEEDING EXPERIMENTS.

In 1914 and 1917 the grain sorghums in the varietal experiments were duplicated on different dates. The first seeding in 1914 was made on May 11, while the second seeding was made on June 2, or 22 days later. In 1917 the main varietal plats were seeded May 15 and the duplicate plats on May 23, or 8 days later. The data previously presented are for the earlier seedings. The behavior of the varieties when seeded at different times differs greatly, and certain adaptations and limitations of varieties to climatic conditions are emphasized. Data for both seedings in the varietal experiments in 1914 and 1917 are shown in Table 15 for direct comparison.

In 1914 the growing periods of the milos did not vary greatly with the date of seeding. The standard milos were very little taller from the first seeding than from the second, but the earlier seeding of dwarf milo grew approximately 1.5 feet taller than the later plats. In yields of grain the earlier plats were much above the later seeded duplicate plats with one exception. Standard White milo (C. I. No. 352) made a higher yield of grain from the later seeding than on the earlier plat, due to the fact that the earlier plat was damaged by birds to a considerable degree.

TABLE 15.—*Data obtained in the varietal experiments with grain sorghums at the Woodward Field Station by sowing on two dates in 1914 and 1917.*

[Data in columns numbered 1 are for the first seeding, those in columns numbered 2 for the second seeding. The first seeding in 1914 was made on May 11 and the second seeding on June 2. In 1917 the first seeding was made on May 15 and the second on May 23.]

Group and variety.	C. I. No.	Growing period (days).						Height (feet).		Yields per acre.			
		Vegetative.		Fruiting.		Total.				Total crop (pounds).		Grain (bushels).	
		1	2	1	2	1	2	1	2	1	2	1	2
1914.													
Milo:													
Standard Yellow	77	72	74	30	28	102	102	4.75	4.50	5,100	5,018	13.6	8.1
Do	223	72	74	30	28	102	102	4.75	4.25	5,328	4,545	16.5	4.1
Do	234	72	74	30	28	102	102	4.75	4.25	2,790	4,208	18.2	2.7
Dwarf Yellow	149	72	74	31	28	103	102	3.75	2.25	3,753	3,510	13.7	3.1
Do	332	72	74	31	28	103	102	3.75	2.00	3,690	3,668	9.9	2.3
Do	359	72	74	31	28	103	102	3.75	2.25	2,565	3,668	7.9	2.7
Standard White	352	75	74	30	28	105	102	5.00	4.50	4,428	4,680	8.3	10.9
White durra	81	61	60	30	26	91	86	4.75	4.75	1,827	2,520	9.5	16.7
Feterita	182	63	62	39	29	102	91	4.75	4.25	1,251	3,015	9.9	10.1
Kaoliang:													
Mukden	190	65	65	26	19	91	84	5.75	5.50	2,225	3,128	12.9	15.5
Blackhull	.....	68	67	28	25	96	92	4.75	4.50	2,025	2,543	12.5	11.3
Manchu	171	63	62	26	21	89	83	5.00	5.00	1,134	2,025	12.0	9.3
Do	328	51	53	27	28	78	81	4.50	4.50	1,593	1,643	5.6	4.7
Shantung Dwarf	293	68	69	24	24	92	93	2.75	2.50	1,179	1,665	5.4	7.0
Valley	309	66	62	30	30	96	92	4.75	5.00	1,809	2,298	9.4	14.7
Parker	424	63	60	26	26	89	86	4.25	4.50	1,818	2,183	7.9	10.5
Shallu	85	95	84	18	18	113	102	.....	.....	4,572	3,758	6.1	4.3
1917.													
Milo:													
Standard Yellow	234	107	105	43	37	150	142	5.25	5.50	5,805	5,400	19.5	19.8
Dwarf Yellow	332	107	105	43	37	150	142	3.00	3.00	4,650	3,225	15.8	16.9
Do	359	107	104	43	38	150	142	3.00	3.00	4,275	3,600	18.0	18.1
Standard White	352	107	105	43	37	150	142	5.25	5.50	5,985	5,250	18.9	18.7
Feterita	182	106	80	36	61	142	141	4.75	4.25	4,050	3,375	13.6	14.3
Kafir:													
Blackhull	71	120	109	30	33	[1] 150	[1] 142	5.00	5.50	8,500	2,475	29.3	9.5
Do	204	108	104	42	38	150	142	5.00	5.00	5,850	3,975	22.3	15.5
Dawn	340	108	104	42	38	150	142	4.75	4.50	8,505	6,825	33.6	24.8
Sunrise	472	108	104	42	38	150	142	7.00	6.00	10,125	7,125	36.9	26.0
White	370	104	107	46	35	150	142	4.50	4.50	5,400	4,425	26.6	15.8
Dwarf White	566	109	106	41	36	150	142	4.00	4.00	5,175	3,825	24.0	19.9
Tall White	566	109	106	41	36	150	142	8.00	6.75	6,750	3,825	27.6	19.5
Red	34	109	108	41	34	150	142	5.50	5.00	8,300	5,550	30.0	22.3
Kaoliang:													
Blackhull	.....	108	96	34	46	142	142	5.25	5.50	4,815	4,275	18.3	21.7
Manchu	171	105	91	34	44	139	135	5.00	4.50	2,610	2,100	2.9	6.7
Valley	309	108	95	34	41	142	136	5.50	4.75	2,430	2,325	3.4	9.4
Miscellaneous:													
Shallu	85	116	115	34	[2] 27	150	[2] 142	6.50	6.00	6,165	4,275	22.8	12.6
Darso	615	97	102	53	40	150	142	4.50	4.25	5,950	4,125	25.7	20.9
Schrock	616	110	107	40	35	[3] 150	[4] 142	4.50	4.75	7,400	4,650	29.3	18.6

[1] First seeding 50 per cent ripe, second seeding 25 per cent ripe when the first killing frost occurred on Oct. 12.
[2] Plat 25 per cent ripe on Oct. 12, when the killing frost occurred.
[3] Plat 60 per cent ripe when the first frost occurred.
[4] Plat 40 per cent ripe when the first frost occurred.

White durra in the later-sown plat matured in 5 days less time and made a considerably higher yield than the earlier plat. Feterita matured in 11 days less time and although the grain yields were almost the same from the two seedings the total crop yield was more than twice as much from the later seeding.

The kafirs in the later seeding failed to mature grain, hence results for them are not included in the table. The kaoliangs in general required less time in which to mature grain when seeded late, though there were one or two exceptions. Four of the seven kaoliangs made higher grain yields when seeded on June 2 than when seeded on May 11. All of the kaoliangs made higher yields of total crop from the late seeding.

Table 15 also shows data for the two sets of varietal plats sown in 1917, when the second seeding was made eight days after the first. The season of 1917 was very dry during July, and the sorghums practically stopped growth until rains fell in August. A study of the data shows that the milos and feterita varied but little in grain yield for the two seedings, though there is a slight advantage in favor of the later seeded plats. On the other hand, the total crop yields are in favor of the earlier seeding. The kafirs produced decidedly higher grain and total crop yields from the first seeding, as did shallu, darso, and Schrock sorghum. The kaoliangs made better grain yields from the second seeding than from the first, though the total crop yields were in favor of the earlier seeding.

From the foregoing data it is seen that quite different results may be obtained from the same variety when seeded at different dates.

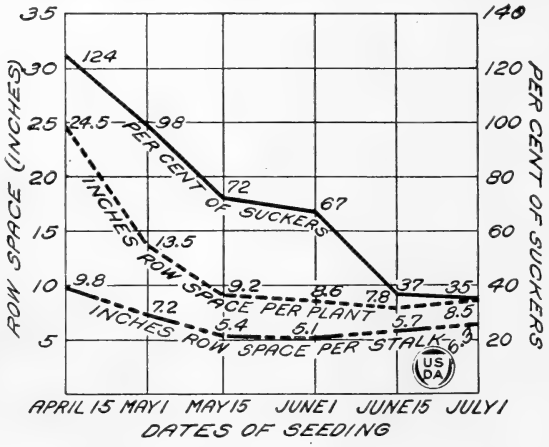

FIG. 5.—Diagram showing the relation of row space per plant and per stalk to the percentage of suckering for the different dates of seeding of Dwarf Yellow milo, based on 5-year averages, 1917 to 1921, inclusive.

To study the effects of time of seeding on the grain sorghums and to determine the best average date on which to seed them, date-of-seeding experiments with two varieties were started at the Woodward Field Station in 1917. The varieties used for these date-of-seeding experiments were Dwarf Yellow milo (C. I. No. 332) and Sunrise kafir (C. I. No. 472). Dwarf Yellow milo was selected as a typical dwarf milo to represent the durra-milo group in these experiments. Sunrise kafir was selected as the representative of the kafir group because it had produced the highest grain yields among the kafirs in the varietal experiments. The earliness and total crop yields of Sunrise kafir also were considered.

In a preliminary date-of-seeding test conducted in 1916 Dwarf Yellow milo and Sunrise kafir were sown on three dates at intervals of approximately two weeks. This experiment showed that one month did not cover the possible limits of seeding for these crops under the conditions at the Woodward Field Station. In 1917 more complete date-of-seeding experiments were started. The first or earliest sowing was made about the middle of April, followed by others at intervals of 14 or 15 days as nearly as conditions permitted until the last date, on or about July 1. The two varieties have been seeded on six different dates each year since 1917. Though it has been impossible because of weather conditions always to make a seeding on the exact date planned, this schedule has been followed closely, and the average dates of seeding during the several years are close to those planned. In view of the results obtained up to 1919,

three more varieties of grain sorghums were added that year to the date-of-seeding experiments—Dawn kafir (C. I. No. 340), feterita (C. I. No. 182), and Blackhull kaoliang (C. I. No. 310). In 1921 Reed kafir (C. I. No. 628) was added, to obtain data on its behavior as compared with the other sorghums when sown on different dates.

The block of land used for date-of-seeding experiments is all prepared before seeding the earliest plats. The plats to be sown on each date are worked down before seeding, usually with a spring-tooth harrow, and the seed is drilled deep enough to reach moist soil. Land for the later dates is kept free from weeds by working with a spring-tooth or disk harrow when necessary. The date-of-seeding plats have varied in size from 6 to 10 rows, 44 inches apart and 132 feet long, one row equaling 0.0111 (one-ninetieth) acre. When any border effect between plats is apparent the outside rows of the adjoining plats are discarded.

The agronomic data for the date-of-seeding experiments are presented in Tables 16 to 20. Table 21 is a summary of the yields of all varieties included in the date-of-seeding experiments.

DWARF YELLOW MILO.

Table 16 shows the agronomic data for Dwarf Yellow milo in the date-of-seeding experiments. This table shows that the stands obtained from the middle of April and first of May seedings have been thinner than those obtained from the sowings made on the later dates. These poor stands have been due to the cool, moist condition of the soil, which causes the seed to decay rather than germinate, a fact which should be considered in early seeding. The other dates have been fairly comparable in any year and between the different years. In most years the thin stands of the earlier dates have been compensated by suckering, so that in general the differences in stands are not a limiting factor of yield. Figure 5 shows the relation of the date of seeding to the percentage of suckers produced.

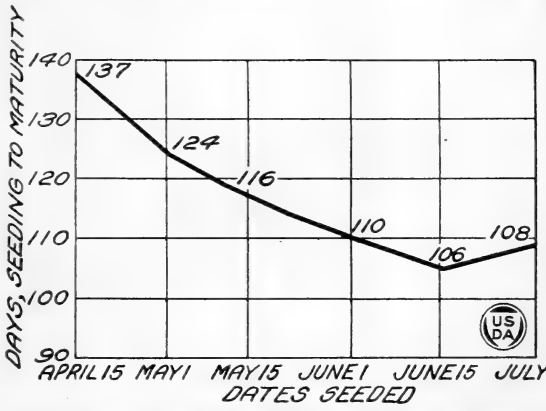

FIG. 6.—Diagram showing average number of days from seeding to ripening for Dwarf Yellow milo sown on different dates in the date-of-seeding experiment during the 5-year period from 1917 to 1921, inclusive.

The total growing period has been longest from the mid-April seeding in each of the 5 years. The extremes in the length of total growing period were 169 days for the middle of April seeding in 1917 and 97 days for the mid-June seeding in 1919. The average number of days in the total growing periods for the six dates of seeding is shown graphically in Figure 6. It is apparent that the number of days required from seeding to maturity decreases as the date of seeding advances from the middle of April to the middle of June,

but milo sown on July 1 requires a longer growing period than that sown on June 15. This increase is due to the temperature gradually falling after the middle of August, at which date the July 1 seeding is not headed.

TABLE 16.—*Agronomic data in the date-of-seeding experiments with Dwarf Yellow milo at the Woodward Field Station during the 6-year period from 1916 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 58 pounds.]

Date of seeding.	Row space.		Length of period.			Stalks per plant.	Erect heads.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.						Total crop.	Grain.	
1916:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bus.*
May 1	6.89	5.84	68	29	97	1.18	.....	78.1	4.0	37.1	2,400	890	15.3
May 15	6.14	5.64	66	37	103	1.09	.....	58.6	3.0	22.8	2,025	461	8.0
June 1	7.13	6.68	69	49	118	1.07	.....	65.6	2.5	23.5	2,295	540	9.3
1917:													
April 16	18.84	6.48	122	47	169	2.91	59.0	95.2	3.0	27.2	3,600	979	16.9
May 2	14.67	5.54	106	54	160	2.65	62.2	95.3	3.0	24.0	5,119	1,226	21.1
May 15	9.70	5.00	108	40	148	1.94	57.4	88.4	3.5	26.2	4,781	1,254	21.6
June 2	9.64	6.09	92	40	132	1.58	52.6	87.2	4.0	30.1	5,119	1,541	26.6
June 22	9.19	7.13	84	[1] 28	112	1.29	70.5	93.1	4.8	27.7	5,569	1,541	26.6
July 3	10.22	6.99	80	[1] 21	101	1.46	74.2	92.2	4.5	14.9	5,344	799	13.8
1918:													
Apr. 16	62.38	17.79	85	42	127	3.35	91.3	93.6	3.0	17.6	1,856	326	5.6
May 1	14.08	6.75	79	33	112	2.09	99.7	54.1	3.0	5.4	2,194	118	2.0
May 14	11.27	6.46	80	40	120	1.75	98.8	34.7	2.5	4.4	1,875	83	1.4
June 1	8.43	5.30	77	30	107	1.59	100.0	22.4	2.8	3.7	2,625	98	1.7
June 15	8.14	6.20	75	27	102	1.31	100.0	48.6	3.0	11.4	2,700	308	5.3
July 1	10.77	8.43	85	39	124	1.28	81.8	66.3	2.8	17.3	3,536	611	10.5
1919:													
Apr. 15	16.54	9.99	101	35	136	1.66	89.4	93.4	4.0	31.0	3,938	1,221	21.0
Apr. 30	17.20	12.79	93	29	122	1.35	94.0	89.4	4.0	34.1	3,263	1,114	19.2
May 14	9.93	5.78	84	26	110	1.72	99.4	85.0	3.5	34.9	5,625	1,963	33.8
May 31	11.65	5.44	75	25	100	2.14	98.8	87.8	3.8	33.9	6,975	2,363	40.7
June 14	6.78	4.85	67	30	97	1.40	99.5	87.2	3.5	29.0	6,019	1,744	30.1
June 30	7.77	5.36	62	38	100	1.45	98.6	82.1	3.8	33.9	5,006	1,699	29.3
1920:													
Apr. 15	14.26	8.20	92	41	133	1.74	79.8	98.1	4.5	26.9	3,769	1,013	17.4
May 1	8.37	4.80	81	36	117	1.74	93.8	82.2	4.5	21.3	3,525	750	12.9
May 17	7.02	3.79	70	35	105	1.85	99.0	74.5	4.8	21.0	5,850	1,230	21.2
June 1	6.45	3.90	66	39	105	1.65	98.4	73.3	3.5	20.6	7,725	1,590	27.4
June 15	6.65	4.98	66	48	114	1.34	94.7	92.4	4.2	29.0	11,122	3,227	55.6
July 1	6.15	4.78	65	33	[2] 98	1.28	70.3	95.9	4.9	33.0	9,386	3,099	53.4
1921:													
Apr. 18	10.46	6.66	83	38	121	1.57	75.5	94.7	4.8	46.0	3,544	1,631	28.1
Apr. 30	13.10	6.22	79	30	109	2.11	68.7	98.4	5.1	43.3	5,119	2,216	38.2
May 16	8.03	5.89	73	26	99	1.36	90.6	97.2	4.9	39.3	5,265	2,070	35.7
June 1	6.64	4.78	71	34	105	1.39	93.6	95.5	5.5	35.1	8,100	2,841	49.0
June 15	8.17	5.44	72	33	105	1.50	61.0	96.7	4.5	38.0	7,586	2,880	49.6
July 1	7.77	6.15	67	52	119	1.27	95.1	93.1	5.0	34.0	6,171	2,096	36.1
5-year average, 1917 to 1921:													
Apr. 16	24.50	9.82	97	41	137	2.24	79.0	96.2	3.9	29.7	3,341	1,034	17.8
May 1	13.48	7.22	88	36	124	1.97	83.7	83.9	3.9	25.6	3,844	1,085	18.7
May 15	9.19	5.38	83	33	116	1.72	89.0	76.0	3.8	25.2	4,679	1,320	22.7
June 1	8.55	5.10	76	34	110	1.67	88.7	73.2	3.9	24.7	6,109	1,687	29.1
June 15	7.79	5.72	73	33	105	1.37	85.1	83.6	4.0	27.0	6,599	1,940	33.4
July 1	8.54	6.34	72	37	108	1.35	84.2	85.9	4.2	26.6	5,889	1,661	28.6

[1] Milo on plats sown on June 22 and on July 3 about 50 per cent and 25 per cent ripe, respectively, when the first frost occurred on Oct. 12.
[2] Not fully ripe when harvested.

The proportion of erect heads has varied greatly in different years, and in certain years there has been a great variation as between dates. On the average the percentage of erect heads was highest from the May 15 and June 1 seedings, being 89 and 88.7 per cent, respectively.

In the height of plants the range has been from 2.5 to 5.5 feet. The range as between the different years has naturally been much greater than between the different dates. The average height of

plants was 2.85 feet for the six dates in 1918 and 5.05 feet in 1921, while the 5-year average height for individual dates varies only between 3.8 and 4.2 feet. The May 15 seeding averaged 3.8 feet in height for the 5 years and the July 1 date averaged 4.2 feet.

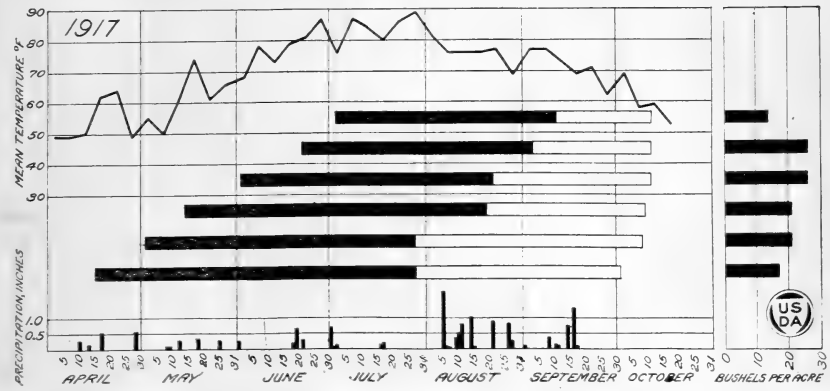

FIG. 7.—Diagram showing (1) at bottom, daily precipitation (in inches) from April 1 to October 31, 1917; (2) central portion, the length of the growing (solid bars) and fruiting (open bars) periods of six successive seedings of Dwarf Yellow milo; (3) at top, mean temperature (in degrees F.) by 5-day periods from April 1 to October 31; (4) at right, acre yield (in bushels) from each of the six seedings.

The percentage of stalks headed has also varied more in different years than as between the different dates of seeding. The stalks headed averaged 53.8 per cent for the six dates in 1918 and 95.9 per

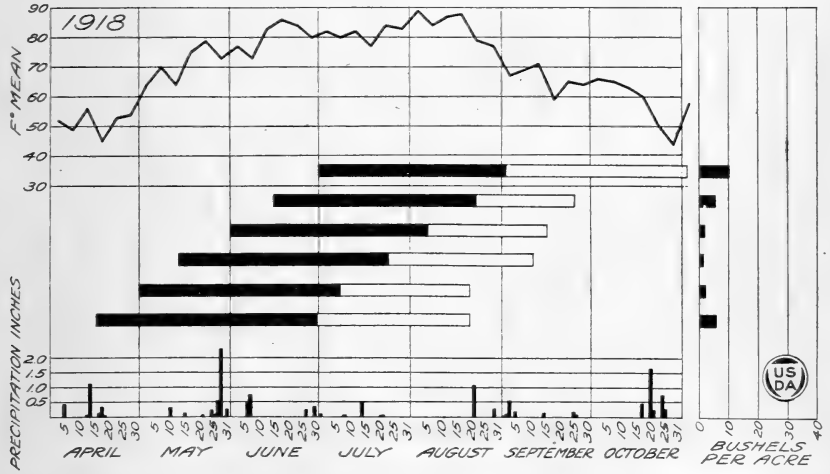

FIG. 8.—Diagram showing (1) at bottom, daily precipitation (in inches) from April 1 to October 31, 1918; (2) central portion, length of growing (solid bars) and fruiting (open bars) periods of six successive seedings of Dwarf Yellow milo; (3) at top, mean temperature (in degrees F.) by 5-day periods from April 1 to October 31; (4) at right, acre yield (in bushels) from each of the six seedings.

cent in 1921. The April 15 date has averaged 96.2 per cent of stalks headed, while the June 1 date has averaged but 73.2 per cent for the 5 years. This low average is due in large part to an almost total failure to produce heads from this seeding in 1918.

The yield of grain in pounds and bushels per acre is shown for each date. In the five years these experiments have been conducted no single date of seeding has made the highest yield every year. In order to determine the best date on which to seed the crop to make the highest grain yield, the average of the different dates for the

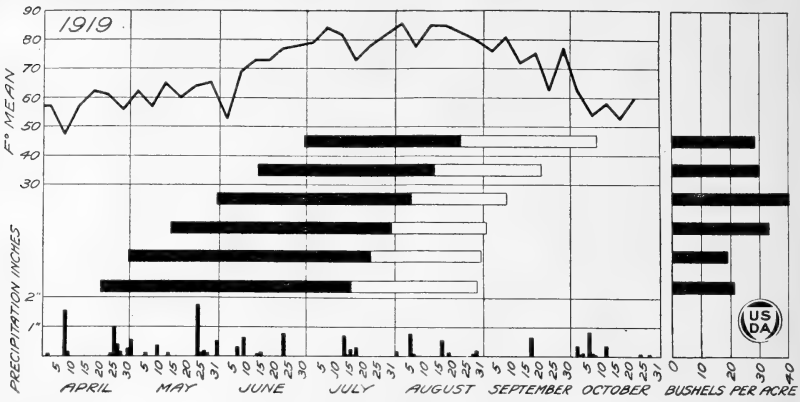

FIG. 9.—Diagram showing (1) at bottom, daily precipitation (in inches) from April 1 to October 20, 1919; (2) central portion, length of growing (solid bars) and fruiting (open bars) periods of six successive seedings of Dwarf Yellow milo; (3) at top, mean temperature (in degrees F.) by 5-day periods from April 1 to October 20; (4) at right, acre yield (in bushels) from each of the six seedings.

five years must be considered. In 1917 the June 1 and June 15 dates produced the highest yields, 26.6 bushels from each plat. In 1918 the July 1 date made the best grain yield; in 1919 the June 1 date; in 1920 the June 15 date, with the July 1 date a close second; and

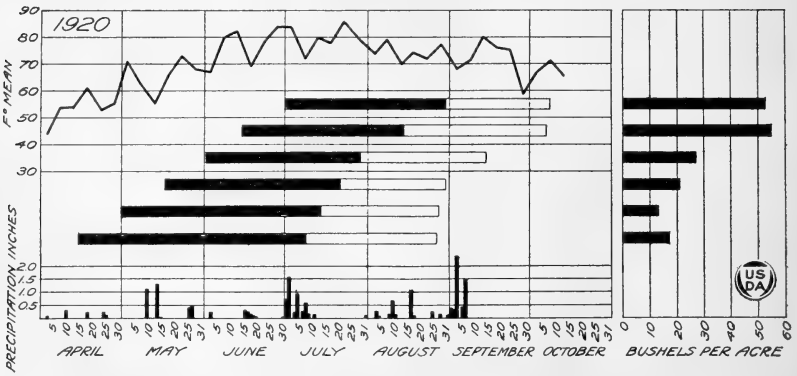

FIG. 10.—Diagram showing (1) at bottom, daily precipitation (in inches) from April 1 to October 15, 1920; (2) central portion, length of growing (solid bars) and fruiting (open bars) periods of six successive seedings of Dwarf Yellow milo; (3) at top, mean temperature (in degrees F.) by 5-day periods from April 1 to October 15; (4) at right, acre yield (in bushels) from each of the six seedings.

in 1921 the June 15 date was the high yielder and the June 1 date a close second. Thus, in the five years, the June 1 date has made the highest grain yield one year and in two others it has tied with the June 15 date. The June 15 date likewise has made the highest yield in one year and tied with the June 1 date in two years, while in one

year the July 1 date made the highest grain yield. The 5-year average yields for the different dates are given in Table 16. The highest yielding plat of Dwarf Yellow milo in 1921, the June 15 seeding, is shown in Plate IV, Figure 2.

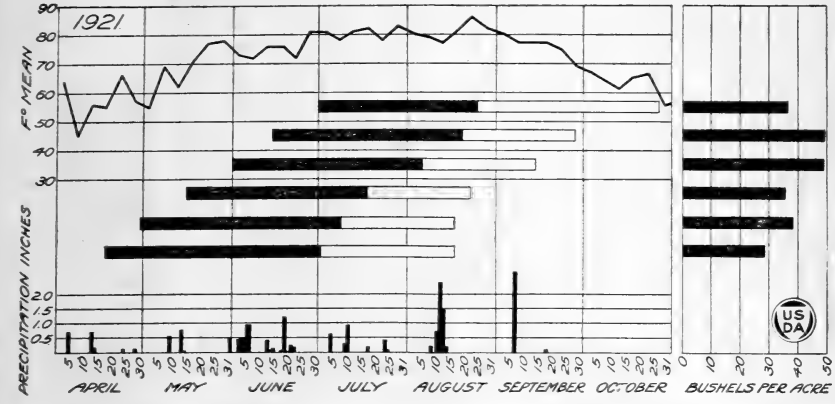

FIG. 11.—Diagram showing (1) at bottom, daily precipitation (in inches) from April 1 to October 31, 1921; (2) central portion, length of growing (solid bars) and fruiting (open bars) periods of six successive seedings of Dwarf Yellow milo; (3) at top, mean temperature (in degrees F.) by 5-day periods from April 1 to October 31; (4) at right, acre yield (in bushels) from each of the six seedings.

There appears to be a critical period in the development of the milo crop, which extends from the time the head is forming in the boot until the seeds have formed. Should this stage fall during a dry period, the yield will be reduced. To show the relation between the dates of seeding, the growing periods, rainfall, and yields, Figures

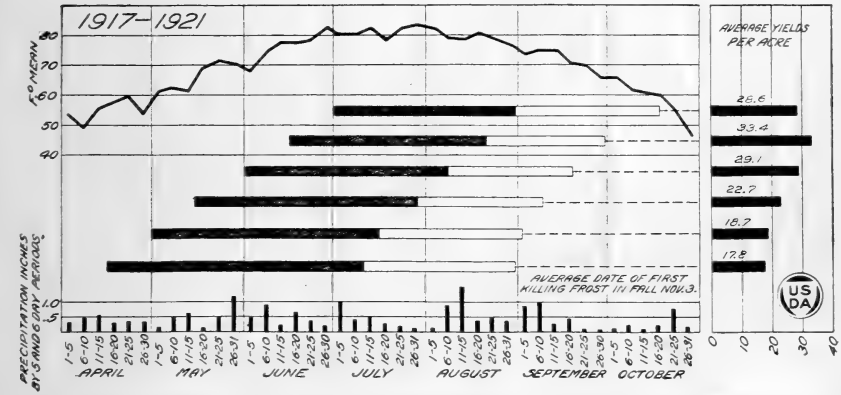

FIG. 12.—Diagram showing (1) at bottom, average precipitation (in inches) by 5-day periods from April 1 to October 31 during the five years from 1917 to 1921, inclusive; (2) central portion, average length of growing (solid bars) and fruiting (open bars) periods of six successive seedings of Dwarf Yellow milo during this 5-year period; (3) at top, average mean temperature (in degrees F.) by 5-day periods from April 1 to October 31 during the five years from 1917 to 1921, inclusive; (4) at right, average acre yield (in bushels) from each of the six seedings in the 5-year period.

7 to 11 are presented. The dates of first heading are given instead of the full heading dates, as the former show more nearly the beginning of the supposed critical period in the development of the milo plant. Figure 12 shows the average data for the 5 years, the rainfall and temperature being given by 5-day and 6-day periods averaged

for the 5 years. It is to be noted that during the last 16 days of July and the first 5 days of August the rainfall has been very low, this period also being marked by high average temperature. The critical period of milo seeded during May falls in this dry period, as does the latter part of the critical period of the April 15 seeding. The plat seeded on June 1 makes boot about the time the August rains start. Under average conditions it is seen that milo sown on the mid-June date reaches its critical stage about the middle of August, when, on the average, rains have occurred. The plat sown on July 1 is frequently immature at the time of the first killing frost, hence its yield is decreased. The conditions described are average for the 5-year period from 1917 to 1921, the period during which these date-of-seeding experiments have been conducted. For this period the highest average yield, 33.4 bushels, was produced from the June 15 seeding, the June 1 and July 1 seedings ranking next with 29.1 and 28.6 bushels, respectively. Yields of the total crop vary consistently with the yields of grain.

SUNRISE KAFIR.

The agronomic data recorded for Sunrise kafir in the date-of-seeding experiments are presented in Table 17, and the annual and average grain yields for the different dates are summarized in Table 21. The same difficulty has been experienced in obtaining stands of Sunrise kafir from the earlier dates of seeding as with Dwarf Yellow milo. In 1918 the stand from the April 15 seeding was very poor and was so thin that suckering could not overcome the difference. In other years the stands have been fairly comparable for the different dates. The desired stand for Sunrise kafir was one plant for each 12 inches of row space, and under these conditions suckering has been rather extensive.

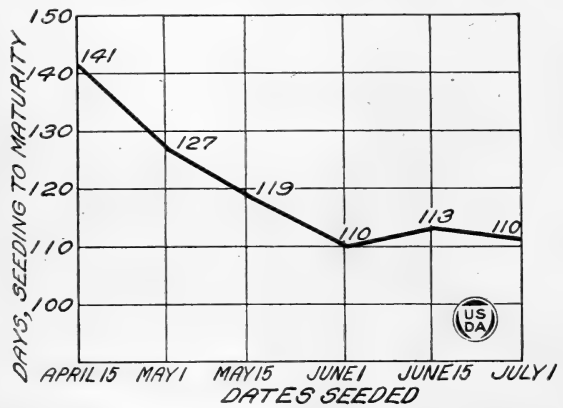

FIG. 13.—Diagram showing average number of days from seeding to ripening for Sunrise kafir sown on different dates in the date-of-seeding experiment during the 5-year period from 1917 to 1921, inclusive.

The total growing period for Sunrise kafir has averaged longer than that for Dwarf Yellow milo. The longest period has been required by the earlier dates. The shortest total growing period for Sunrise kafir has been that for the June 1 seeding, 110 days, the same as that for Dwarf Yellow milo seeded on the same date. The June 15 seeding has required a longer period in which to mature than that of June 1, while the July 1 seeding has been caught by frost in two of the five years and its growing period has been shortened thereby, as the crop was not fully matured. Figure 13 represents the average length of the total growing period required by Sunrise kafir sown on the different dates in the five years.

TABLE 17.—*Agronomic data in the date-of-seeding experiments with Sunrise kafir at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 60 pounds.]

Date of seeding.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yield per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
1916:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
May 1	7.44	5.98	74	39	113	1.24	75.9	5.5	20.4	4,700	960	16.0
May 15	6.59	6.46	78	31	109	1.02	77.5	4.5	14.6	4,331	630	10.5
June 1	5.80	5.70	67	45	112	1.02	73.9	4.5	12.4	4,444	551	9.2
1917:												
Apr. 16	11.79	4.45	118	61	179	2.66	95.7	5.5	23.2	6,975	1,620	27.0
May 2	17.20	5.61	102	61	163	3.07	97.3	5.5	20.0	7,256	1,451	24.2
May 15	11.08	4.43	108	42	150	2.50	96.4	5.8	20.7	8,438	1,744	29.1
June 2	13.42	7.40	91	41	132	1.82	97.7	6.0	23.1	6,863	1,586	26.4
June 22	(1)	(1)	87	25	[2] 112	(1)	(1)	6.0	15.4	5,625	866	14.4
July 3	(1)	(1)	81	20	[2] 101	(1)	(1)	6.0	8.2	5,344	439	7.3
1918:												
Apr. 16	180.0	62.38	88	39	127	3.02	94.7	5.0	21.7	675	146	2.4
May 1	21.07	10.10	86	26	112	2.08	80.9	4.8	20.6	1,969	405	6.7
May 14	16.57	7.54	80	39	119	2.20	58.4	4.5	11.8	3,094	366	6.1
June 1	16.29	12.12	72	33	105	1.35	79.3	4.5	23.8	2,194	523	8.7
June 15	15.83	14.27	80	59	139	1.11	68.2	3.8	18.5	1,286	238	4.0
July 1	15.92	13.80	93	40	133	1.15	47.7	4.0	13.3	1,519	203	3.4
1919:												
Apr. 15	16.74	13.30	105	34	139	1.26	90.3	6.0	17.6	3,206	585	9.7
Apr. 30	19.32	14.30	91	33	124	1.35	85.7	5.5	25.5	2,756	703	11.7
May 14	13.18	6.98	82	28	110	1.89	89.3	5.3	33.3	4,838	1,609	26.8
May 31	13.76	11.00	68	33	101	1.25	91.7	5.0	32.8	4,556	1,501	25.0
June 14	12.17	7.18	62	35	97	1.70	88.5	5.0	28.5	4,894	1,395	23.3
June 30	12.79	7.25	68	35	103	1.77	84.9	6.0	28.0	5,175	1,451	24.2
1920:												
Apr. 15	20.35	10.69	97	40	137	1.91	97.0	6.5	21.8	4,388	956	15.9
May 1	12.76	4.81	84	37	121	2.65	91.2	6.5	22.2	6,225	1,380	23.0
May 17	11.54	4.30	75	31	106	2.68	93.6	6.0	30.3	7,575	2,295	38.3
June 1	12.60	6.35	67	38	105	1.99	94.4	6.2	26.8	6,375	1,710	28.5
June 15	12.32	7.20	66	48	114	1.71	94.1	5.9	34.9	6,450	2,250	37.5
July 1	11.94	9.90	66	32	98	1.21	89.4	6.3	32.6	4,275	1,395	23.3
1921:												
Apr. 18	12.50	9.99	86	35	121	1.26	91.9	6.0	43.0	4,106	1,766	29.4
Apr. 30	14.89	9.47	79	36	115	1.57	97.0	6.2	43.1	4,274	1,841	30.7
May 16	14.66	7.26	70	40	110	2.02	94.5	6.5	31.4	6,600	2,070	34.5
June 1	11.22	7.08	64	42	106	1.58	96.0	6.1	36.8	5,700	2,100	35.0
June 15	12.69	10.52	63	42	105	1.21	93.4	5.7	42.0	[3] 3,750	1,575	26.3
July 1	12.46	7.51	73	46	119	1.66	87.1	5.9	29.2	4,875	1,425	23.7
5-year average, 1917 to 1921:												
Apr. 16	15.88	20.16	99	42	141	2.02	93.9	5.8	25.5	3,870	1,015	16.9
May 1	17.05	8.86	88	39	127	2.15	90.4	5.7	26.3	4,496	1,156	19.3
May 15	13.41	6.10	83	36	119	2.26	86.4	5.6	25.5	6,109	1,617	27.0
June 1	13.46	8.79	72	37	110	1.60	91.8	5.6	28.7	5,138	1,484	24.7
June 15	[4] 13.25	[4] 9.79	72	42	113	[4] 1.43	[4] 86.1	5.3	27.9	4,401	1,265	21.1
July 1	[4] 13.28	[4] 9.62	76	35	111	[4] 1.45	[4] 77.3	5.6	22.3	4,238	983	16.4

[1] Counts not made, the crop being immature when harvested.
[2] About 20 per cent of the June 22 seeding and 5 per cent of the July 3 seeding was ripe at the time of the first frost on Oct. 12.
[3] The crop from the June 15 date in 1921 was blown down badly by a windstorm, and much fodder was left in the field.
[4] Average for 4 years only.

Sunrise kafir sown on May 15 has produced the highest number of suckers per plant, though its stand was practically as thick as that of any of the other dates. Figure 14 shows the relation between the date of seeding and the percentage of suckers. In the five years the May 15 seeding has averaged one plant to each 13.41 inches of row space and has produced an average of 1.26 suckers per plant; the plat sown on May 1 has averaged one plant to each 17.05 inches and has produced 1.15 suckers per plant; and the June 1 seeding has averaged one plant to each 13.46 inches and produced but 0.6 sucker per plant. It appears that growing conditions for Sunrise kafir sown about May 15 are such as to cause the plants to produce a high percentage of

suckers and that the high percentage of suckering is not due entirely to thin stands.

In height the range has been from 3.8 to 6.5 feet in the different years. The height and its variations are not significant, the variation in average height for the 5-year period being only that between 5.3 and 5.8 feet.

The yields of grain obtained are more consistent for Sunrise kafir than for Dwarf Yellow milo. During the five years, the May 15 seeding has produced the highest yields in three years and in a fourth year, 1921, it made but 0.5 bushel less than the June 1 seeding, which was the highest yielder. In two of the five years the June 1 seeding yielded highest. From these facts it appears that the best date for seeding Sunrise kafir under conditions similar to those at the Woodward Field Station is from May 15 to 25. The period during which Sunrise kafir may be seeded to make the best returns probably extends from about May 5 to 25.

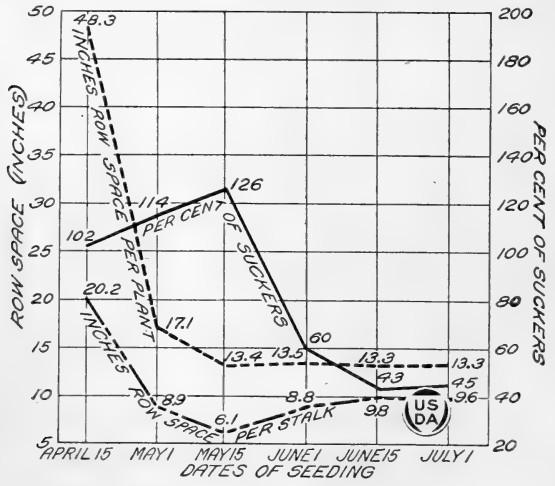

FIG. 14.—Diagram showing relation of row space per plant and per stalk to percentage of suckering for different dates of seeding Sunrise kafir, based on 4-year averages, 1918 to 1921, inclusive.

As kafir is better than milo for forage, the yields of the total crop are also of importance. The May 15 seeding exceeded any other seeding by almost half a ton to the acre, the average total production from this seeding being 6,109 pounds per acre. The June 1 seeding ranked next, followed by the May 1 and June 15 seedings. The June 15 plats of Dwarf Yellow milo in the same five years produced an average total crop of 6,599 pounds.

DAWN KAFIR.

Date-of-seeding experiments have been conducted with Dawn kafir since 1919. The agronomic data for this variety for the three years are presented in Table 18. The annual and average grain yields are shown for comparison with other varieties in Table 21.

Dawn kafir was not seeded on April 15 in these experiments, as it had been proved from the test with Sunrise kafir that April 15 is too early to sow kafir and obtain fair stands. In 1920 a plat of Dawn kafir was seeded on July 1, but from this one seeding and from the results obtained from the July 1 sowing of Sunrise kafir it was apparent that July 1 is too late to seed kafir and expect a well-matured grain crop. As the April 15 sowing was not included in the experiment with Dawn kafir, the stands obtained on the Dawn kafir plats were very uniform and were comparable between years and between different dates in the same year.

From a comparison of the number of stalks per plant it is apparent that Sunrise kafir has a tendency to produce more suckers than Dawn kafir under all conditions which existed during the three years from 1919 to 1921 and for the dates when both Dawn and Sunrise kafirs were seeded.

TABLE 18.—*Agronomic data in the date-of-seeding experiments with Dawn and Reed kafirs at the Woodward Field Station for the years 1919, 1920, and 1921.*

[In the statement of yields of grain per acre the bushel is rated at 60 pounds.]

Variety and date of seeding.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
DAWN KAFIR.												
1919:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
Apr. 30	14.67	12.42	90	34	124	1.18	81.5	3.8	22.6	3,038	686	11.4
May 14	12.11	7.45	80	30	110	1.67	82.7	3.8	30.8	4,275	1,316	21.9
May 31	12.85	11.23	68	33	101	1.15	93.4	3.5	33.2	4,275	1,418	23.6
June 14	12.21	8.54	62	35	97	1.43	87.7	3.8	29.5	4,275	1,260	21.0
1920:												
May 1	12.08	5.61	84	37	121	2.15	90.2	4.5	32.8	6,000	1,965	32.8
May 17	11.87	4.47	75	31	106	2.66	87.3	4.3	34.8	6,300	2,190	36.5
June 1	12.67	7.84	67	38	105	1.62	95.3	4.1	37.0	5,500	2,055	34.3
June 15	12.73	9.74	66	48	114	1.31	92.1	4.0	38.7	5,500	2,145	35.8
July 1	11.87	10.26	66	[1] 32	98	1.16	86.0	4.5	25.9	5,100	1,320	22.0
1921:												
Apr. 30	14.67	12.08	76	39	115	1.21	[2] 121.1	4.1	49.8	3,675	1,830	30.5
May 16	14.49	8.86	70	40	110	1.64	98.6	4.6	39.5	5,475	2,160	36.0
June 1	11.40	9.37	64	42	106	1.22	95.0	4.1	40.0	4,875	1,950	32.5
June 15	13.70	11.89	63	42	105	1.15	93.9	4.1	40.4	4,125	1,645	27.4
3-year average, 1919 to 1921:												
Apr. 30	13.81	10.04	83	37	120	1.52	97.6	4.1	35.1	4,238	1,494	24.9
May 15	12.82	6.93	75	34	109	1.97	89.5	4.2	35.0	5,350	1,889	31.5
June 1	12.31	9.48	66	38	104	1.33	94.6	3.9	36.7	4,883	1,808	30.1
June 15	12.88	10.06	64	42	105	1.30	91.2	4.0	36.2	4,633	1,683	28.1
REED KAFIR.												
1921:												
Apr. 30	15.00	13.60	84	31	115	1.10	[2] 105.7	6.1	42.4	5,025	2,130	35.5
May 16	12.54	11.48	72	38	110	1.10	97.0	6.1	36.6	6,225	2,280	38.0
June 1	13.03	12.23	68	38	106	1.07	96.1	5.2	43.7	5,325	2,325	38.7
June 16	13.28	12.27	67	38	105	1.08	96.7	5.3	50.2	3,525	1,770	29.5

[1] The July 1 seeding of Dawn kafir in 1920 was not ripe when harvested.
[2] Some stalks of the Apr. 30 seeding produced more than one head.

During the three years when date-of-seeding plats of both Dawn and Sunrise kafir were grown the ratio of height of Dawn to Sunrise kafir was 1 to 1.40 in 1919, 1 to 1.44 in 1920, and 1 to 1.45 in 1921, or an average for the three years of 1 to 1.43. The total growing periods have been the same for Dawn and Sunrise kafir.

From the results for the three years it appears that Dawn kafir makes its highest average yield when seeded on May 15, with the June 1 sowing second highest. Sunrise kafir has consistently made yields of total crop higher than Dawn.

REED KAFIR.

Reed kafir (C. I. No. 628) was included in the date-of-seeding experiments in 1921. Results for a single year are not of much value, but the data are presented in Table 18 to show the behavior of this variety. This kafir produced fewer suckers and slightly higher grain yields than either Sunrise or Dawn kafirs when sown on

the same dates. The yields were almost identical from sowing on May 1, May 15, and June 1. Illustrations of Reed and Dawn kafir sown on May 16, 1921, are shown in Plate V, Figure 1.

FETERITA.

Feterita has been included in the date-of-seeding experiments since 1919. The agronomic data for this experiment during the three years from 1919 to 1921, inclusive, are given in Table 19. The annual and average yields of grain are presented in Table 21 for comparison with other varieties. A plat of feterita sown on June 1, 1921, is shown in Plate V, Figure 2.

Feterita was not seeded on April 15, as stands of the other varieties were difficult to obtain, and a good stand of feterita from early seeding is harder to get than of milo or kafir. Even from the later dates of sowing, the stands of feterita have not been as satisfactory or dependable as those of milo. In 1919 the plat sown on June 15 was the only one which had the desired stand. In 1920 and 1921 the plats sown on all dates with the exception of May 1 were comparable and thick enough.

TABLE 19.—*Agronomic data in the date-of-seeding experiments with feterita at the Woodward Field Station for the years 1919, 1920, and 1921.*

[In the statement of yields of grain per acre the bushel is rated at 58 pounds.]

Date of seeding.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
1919:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
Apr. 30	38.00	16.84	83	39	122	2.26	84.1	5.5	44.5	2,366	1,052	18.1
May 14	12.42	6.71	72	36	108	1.86	98.0	5.8	40.9	4,894	2,003	34.5
May 31	19.78	8.50	59	41	100	2.33	97.7	5.0	40.3	3,825	1,541	26.6
June 14	7.37	4.61	49	42	91	1.60	93.6	5.0	33.2	4,275	1,418	24.4
1920:												
May 1	13.39	5.29	69	36	105	2.53	94.7	4.8	36.2	3,900	1,410	24.3
May 17	7.80	3.18	61	37	98	2.46	94.3	5.5	42.4	4,950	2,100	36.2
June 1	7.96	3.27	53	37	90	2.44	96.3	5.7	37.4	5,850	2,190	37.8
June 15	7.23	4.80	52	45	97	1.50	95.6	5.1	34.5	7,575	2,610	45.0
July 1	7.17	4.05	52	46	98	1.77	95.5	5.7	37.7	6,450	2,430	41.9
July 15	6.33	3.39	54	45	99	1.87	95.0	5.5	38.5	6,075	2,340	40.3
1921:												
Apr. 30	12.77	6.22	68	41	109	2.05	96.5	5.7	38.4	5,700	2,190	37.8
May 16	8.78	5.72	68	31	99	1.54	108.7	6.9	40.0	5,475	2,190	37.8
June 1	8.56	5.19	58	34	92	1.65	95.5	6.2	40.0	5,475	2,190	37.8
June 15	8.41	5.89	56	45	101	1.43	96.2	5.5	40.5	5,700	2,310	39.8
July 1	7.94	5.60	57	40	97	1.42	94.7	5.9	37.2	4,275	1,590	27.3
July 15	(1)	4.68	55	50	105	.....	.....	4.6	28.0	3,938	1,102	19.0
3-year average, 1919 to 1921:												
Apr. 30	21.39	9.45	73	39	112	2.28	91.8	5.3	39.7	3,989	1,551	26.7
May 15	9.67	5.20	67	35	102	1.95	100.3	6.1	41.1	5,106	2,098	36.2
June 1	12.10	5.65	57	37	94	2.14	96.5	5.6	39.2	5,050	1,974	34.1
June 15	7.67	5.10	52	44	96	1.51	95.1	5.2	26.1	5,850	2,113	36.4

[1] The plants in this plat were not counted, as they were badly tangled from storm damage.

A study of the data in Table 19 shows that feterita is inclined to produce more suckers than Dwarf Yellow milo. Feterita also matures grain in a shorter period than dwarf milo. It requires a much shorter period from seeding until heading than dwarf milo, but the ripening period averages longer under similar conditions.

In 1920 and 1921 the June 15 seeding of feterita made the highest yields, while in 1919 the May 15 sowing was the higher yielder.

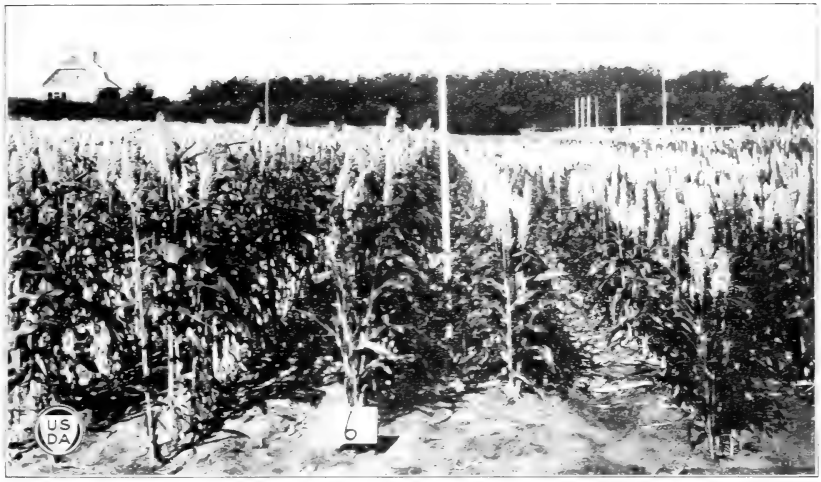

FIG. 1.—PLATS OF KAFIR IN THE DATE-OF-SEEDING EXPERIMENTS.

Seeded on May 16, the Reed kafir (C. I. No. 628, at the left) yielded 38 bushels per acre, and the Dawn kafir (C. I. No. 340, at the right) yielded 36 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

FIG. 2.—PLAT OF FETERITA IN THE DATE-OF-SEEDING EXPERIMENTS.

This plat was seeded on June 1 and yielded 37.8 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

FIG. 1.—PLAT OF DWARF YELLOW MILO IN ROWS 44 INCHES APART.

The plants in this plat were spaced 6 inches apart in the rows. The yield was 41 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

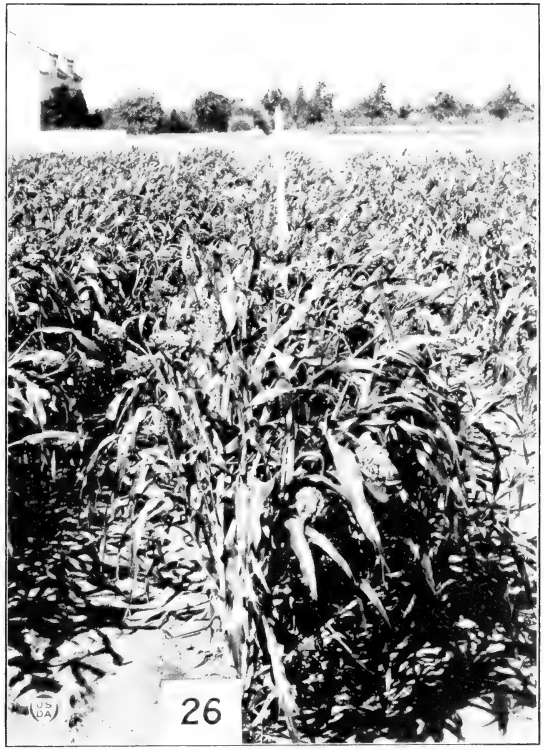

FIG. 2.—PLAT OF DWARF YELLOW MILO IN ROWS 88 INCHES APART.

The plants in this plat were spaced 3 inches apart in the rows. The yield was 42.1 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

Feterita has shown an ability to mature grain when seeded later than Dwarf Yellow milo, and it has possibilities as a crop to be seeded in July for grain. From these data feterita appears to be a consistent grain yielder and to be less influenced by droughty periods than milo.

BLACKHULL KAOLIANG.

Blackhull kaoliang has been sown in the date-of-seeding experiments on the same dates as feterita. The agronomic data recorded for this crop are shown in Table 20, and the grain yields are summarized in Table 21 for comparison with those of other varieties.

The same difficulty has been found with Blackhull kaoliang as with feterita in obtaining stands. Under conditions when the stands are comparable this kaoliang produces fewer suckers than feterita. The length of the total growing period is practically the same, though feterita begins heading a few days earlier than this variety of kaoliang.

Blackhull kaoliang sown on June 15 has made the highest grain yield, though in 1919 this may have been due to the better stand. It may be used as a late grain crop like feterita, though feterita probably will mature grain from later seedings.

TABLE 20.—*Agronomic data in the date-of-seeding experiments with Blackhull kaoliang at the Woodward Field Station for the years 1919, 1920, and 1921.*

[In the statement of yields per acre the bushel is rated at 53 pounds.]

Date of seeding.	Row space.		Length of period.			Stalks per plant.	Stalks headed.	Height of plants.	Grain in crop.	Yields per acre.	
	Plant.	Stalk.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.
1919:	*In.*	*In.*	*Days.*	*Days.*	*Days.*		*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
Apr. 30	100.72	48.56	85	39	124	2.28	70.6	5.8	37.2	1,013	377	6.5
May 14	25.36	13.06	76	34	110	2.02	91.7	5.5	39.7	3,319	1,316	22.7
May 31	17.17	11.08	65	37	102	1.55	93.1	5.3	39.0	3,431	1,339	23.1
June 14	8.00	6.65	54	39	93	1.20	91.9	5.3	41.0	3,544	1,451	25.0
1920:												
May 1	9.32	5.40	78	34	112	1.78	90.5	6.5	30.6	3,675	1,125	19.4
May 17	6.31	4.33	68	31	99	1.46	92.4	6.1	36.3	4,875	1,770	30.5
June 1	6.20	4.19	61	30	91	1.48	89.7	6.3	35.9	5,160	1,850	32.1
June 15	5.91	5.26	60	37	97	1.12	92.5	5.6	34.1	6,900	2,355	40.6
July 1	5.46	5.12	62	36	98	1.07	92.9	6.9	28.9	6,900	1,995	34.4
July 15	6.17	4.45	60	[1] 39	99	1.39	87.0	5.5	30.3	6,525	1,980	34.1
1921:												
Apr. 30	13.04	7.47	77	32	109	1.74	97.9	5.8	39.4	5,250	2,070	35.7
May 16	8.35	5.89	70	29	99	1.42	95.1	6.4	39.4	5,250	2,070	35.7
June 1	8.45	6.34	64	30	94	1.33	95.7	5.9	38.3	5,925	2,265	39.1
June 15	7.48	6.22	59	42	101	1.20	97.4	5.4	39.7	5,925	2,355	40.6
July 1	7.42	6.18	59	38	97	1.20	94.1	5.8	41.9	4,725	1,980	34.1
July 15	[2]	4.28	57	48	105	[2]	[2]	4.5	34.9	3,938	1,373	23.6
3-year average, 1919 to 1921:												
May 1	41.03	20.48	80	35	115	1.94	83.3	6.0	35.7	3,313	1,191	20.5
May 15	13.67	7.76	71	31	103	1.63	93.1	6.0	38.5	4,481	1,719	29.6
June 1	10.61	7.20	63	32	95	1.45	92.8	5.8	37.7	4,839	1,821	31.4
June 15	7.13	6.04	58	39	97	1.18	93.9	5.4	38.3	5,456	2,054	35.4

[1] The July 15 sowing was not fully ripe when harvested.
[2] Stalks only counted for July 15 seeding, plants badly tangled.

COMPARATIVE YIELDS IN DATE-OF-SEEDING EXPERIMENTS.

Table 21 shows the annual and average acre yields from the different dates of seeding for the five varieties which have been grown in these experiments for at least three years. The averages for three, five, and six years are computed where data are available. Dwarf

Yellow milo and Sunrise kafir have been included during the entire five years, and data are available for each of these varieties from sowing on three dates for six years. Dawn kafir, feterita, and blackhull kaoliang have been included in these experiments for only three years.

TABLE 21.—*Yields of grain-sorghum varieties grown in the date-of-seeding experiments at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 60 pounds for the kafirs and at 58 pounds for all other sorghums.]

Variety and date of seeding.	Yields per acre (bushels).								
							Average.		
	1916	1917	1918	1919	1920	1921	3 years, 1919 to 1921.	5 years, 1917 to 1921.	6 years, 1916 to 1921.
Dwarf Yellow milo:									
Apr. 15	.....	16.9	5.6	21.0	17.4	28.1	22.2	17.8	.....
May 1	15.3	21.1	2.0	19 2	12.9	38 2	23.4	18.7	18.1
May 15	8.0	21.6	1.4	33 8	21.2	35.7	30.2	22.7	20.3
June 1	9.3	26.6	1.7	40.7	27.4	49.0	39 0	29.1	25.8
June 15	.....	26.6	5.3	30 1	55.6	49.6	45.1	33.4	.....
July 1	.....	13.8	10.5	29.3	53.4	36.1	39 6	28.6	.....
Sunrise kafir:									
Apr. 15	.....	27.0	2.4	9.7	15 9	29 4	18.3	16.9	.....
May 1	16.0	24.2	6.7	11 7	23 0	33.7	21.8	19 3	18.7
May 15	10 5	29.1	6.1	26.8	38.3	34.5	33.2	27.0	24.2
June 1	9.2	26.4	8.7	25.0	28.5	35.0	29.5	24.7	22.1
June 15	.....	14.4	4.0	23.3	37.5	26 3	29.0	21.1	.....
July 1	.....	7.3	3.4	24.2	23.3	23.7	23.7	16.4	.....
Dawn kafir:									
May 1	.....	.....	.....	11.4	32.8	30.5	24.9	.....	.....
May 15	.....	.....	.....	21 9	36.5	36 0	31 5	.....	.....
June 1	.....	.....	.....	23.6	34.3	32.5	30.1	.....	.....
June 15	.....	.....	.....	21.0	35 8	27.4	28.1	.....	.....
July 1	.....	.....	.....	.....	22.0	.....	.....	.....	.....
Feterita:									
May 1	.....	.....	.....	18.1	24.3	37.8	26.7	.....	.....
May 15	.....	.....	.....	34 5	36 2	37.8	36.2	.....	.....
June 1	.....	.....	.....	26.6	37.8	37.8	34.1	.....	.....
June 15	.....	.....	.....	24.4	45 0	39 8	36.4	.....	.....
July 1	.....	.....	.....	.....	41.9	27.3	.....	.....	.....
July 15	.....	.....	.....	.....	40 3	19 0	.....	.....	.....
Blackhull kaoliang:									
May 1	.....	.....	.....	6 5	19.4	35 7	20 5	.....	.....
May 15	.....	.....	.....	22.7	30 5	35 7	29 6	.....	.....
June 1	.....	.....	.....	23 1	32.1	39.1	31.4	.....	.....
June 15	.....	.....	.....	25 0	40.6	40 6	35.4	.....	.....
July 1	.....	.....	.....	.....	34.4	34.1	.....	.....	.....
July 15	.....	.....	.....	.....	34.1	23.6	.....	.....	.....

Dwarf Yellow milo made its extreme high yield, 55.6 bushels, from the June 15 seeding in 1920 and its extreme low yield, 1.4 bushels, from the May 15 seeding in 1918. In 1917 the June 1 and 15 sowings made the high yields, 26.6 bushels each. In 1918 the crop was almost a failure from all sowings, but that of July 1 made the highest yield. In 1919 the June 1 sowing made the highest yield; in 1920 the June 15 sowing, with that of July 1 second; and in 1921 the June 15 sowing led, with that of June 1 a close second. In the 3-year and 5-year averages the June 15 seeding easily ranks first. In the 5-year average the June 1 seeding ranks second, while in the 3-year average the July 1 seeding ranks second. In the 6-year average, which does not include the June 15 date, the June 1 seeding is the highest. From these results it appears that, for the highest grain yield, Dwarf Yellow

milo should be seeded about the middle of June, though possibly any time in June would be satisfactory.

Sunrise kafir made the highest yields from the May 15 seeding in 1917, 1919, and 1920. In 1918 and 1921 the June 1 sowing produced the highest yields, though none of the sowings made even fair yields in 1918, and in 1921 the plat sown on June 1 outyielded that sown on May 15 by only 0.5 bushel. In the averages for three, five, and six years the May 15 seeding ranks first for Sunrise kafir, with the June 1 seeding second. These results show that the middle of May is the best time to seed Sunrise kafir, with the best seeding period extending toward the latter part of May rather than earlier.

Dawn kafir, for which data for only three years are available, shows results similar to those of Sunrise kafir, though the average yields from sowings on the different dates are closer together than the 3-year averages for the Sunrise kafir.

Feterita during the three years it has been grown in these experiments has made an average yield of 36.4 bushels from seedings on June 15 and 36.2 bushels from the May 15 seedings. Feterita has been a very consistent yielder during the three years it has been included in the date-of-seeding experiments. It must be remembered, however, that these three years have been unusually favorable for grain-sorghum production.

Blackhull kaoliang made the highest yields from the June 15 seeding in each of the three years it was grown.

One fact to be noted in connection with these date-of-seeding results is that in the 5-year averages for the different dates Sunrise kafir has outyielded Dwarf Yellow milo from May 1 and May 15 sowings, but Dwarf Yellow milo has averaged higher than Sunrise kafir when seeded on the other four dates. As mentioned before, the varietal plats have been seeded as near the middle of May as conditions have permitted, and the same result was obtained in the varietal experiments as from the May 15 sowing in the date-of-seeding experiments, i. e., when seeded on or near the middle of May Sunrise kafir makes a higher grain yield than Dwarf Yellow milo seeded at the same time. The 5-year average yields of Dwarf Yellow milo sown on June 1, June 15, and July 1, however, have been higher than the yields of Sunrise kafir sown on May 15, the best date for that crop.

It should be remembered that all plats in the rate-of-seeding experiments were prepared for seeding before any of them were sown and that those sown at the later dates were kept free from weeds until seeding time. Prevention of weed growth conserved moisture and plant food, and results less favorable to late seeding would certainly have been obtained if weeds had been allowed to grow on these late-sown plats. Land which is not to be planted until late May or during June should be prepared in late April or early May and kept clean thereafter if the best results are to be obtained.

These date-of-seeding experiments with several representative varieties of grain sorghum clearly bring out the limitations of a varietal experiment with several groups which respond differently to climatic conditions and under conditions where the possible seeding dates cover a relatively long period. Considering only the varietal experiments, one would be justified in concluding that Sunrise kafir is a surer and higher grain yielder than Dwarf Yellow milo. The

varietal experiments were sown on one date each year, and the plan has been to make this date the same from year to year. It so happened that the date on which the sorghums in the varietal experiments were seeded proved to be the best for Sunrise kafir, but a relatively poor date for Dwarf Yellow milo. According to the date-of-seeding results with the two varieties, Dwarf Yellow milo when seeded on June 15 has outyielded Sunrise kafir when sown on the date most favorable for that crop by an average of 6.4 bushels per acre annually.

SPACING EXPERIMENTS.

Spacing experiments have been conducted with Dwarf Yellow milo (C. I. No. 332) and Sunrise kafir (C. I. No. 472) during the 5-year period from 1917 to 1921, inclusive. The objects of these experiments were to determine the best distance between plants and between rows and to study the effect of the different spacings on these grain sorghums. These experiments consist of two divisions for each of the varieties. The first division included five plats with rows spaced 44 inches apart, the plants being spaced at different distances in the row in each of the five plats. The second division consisted of five plats with rows spaced 88 inches apart. The distance between plants in the row in the second division was half as great as in the corresponding plat of the first division, thus giving the same number of plants per unit area in the corresponding plats in the two divisions.

In these spacing experiments the milo and kafir plats were seeded on the same date in the first three years, these dates being May 22 in 1917, May 27 in 1918, and May 21 in 1919. During the last two years the milo and kafir in the spacing experiments were seeded on different dates. In 1920 the kafir plats were seeded on May 17 and the milo plats on May 26, while in 1921 the kafir plats were seeded on May 17 and the milo plats on June 10. In conducting spacing experiments the plats should be seeded on the date which gives maximum yields for the variety. This was possible only during the year 1921, as the date-of-seeding results were hardly conclusive until 1920. However, the Sunrise kafir in the spacing experiments has been seeded during the period which the date-of-seeding experiments show is most favorable for the production of grain. The Dwarf Yellow milo in the spacing experiments was seeded too early to give maximum grain yields in 1917, 1918, 1919, and 1920, but seeding on June 10 gave very high yields in 1921.

To obtain uniform and comparable stands in the spacing experiments it has been necessary to drill the seed very thick and then thin by hand to the desired distance between plants. This method, though impracticable for farming operations, has proved satisfactory for this experimental work. Thinning should be done as soon as the plants are large enough (4 to 6 inches high) to pull without breaking at the first node. The spacings desired for the plats with rows 44 inches apart were one plant for each 6, 12, 18, 24, and 30 inches of row space and for the plats with rows 88 inches apart one plant for each 3, 6, 9, 12, and 15 inches. Though these spacings were not obtained each year, they have been approximated, as the data show.

For convenience the spacings have been designated as shown in Table 22.

TABLE 22.—*Distances between rows and between plants and number of plants to the acre in spacing experiments with grain sorghums at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

Rate.	Distance (inches) between—		Plants per acre.	Rate.	Distance (inches) between—		Plants per acre.
	Rows.	Plants.			Rows.	Plants.	
No. 1	44	6	24,000	No. 6	88	9	8,000
No. 2	88	3	24,000	No. 7	44	24	6,000
No. 3	44	12	12,000	No. 8	88	12	6,000
No. 4	88	6	12,000	No. 9	44	30	4,800
No. 5	44	18	8,000	No. 10	88	15	4,800

DWARF YELLOW MILO.

FIRST DIVISION, ROWS 44 INCHES APART.

The agronomic data for the Dwarf Yellow milo in the first division of the spacing experiments are presented in Table 23. This table shows that in 1917 and 1918 the 6-inch plat was too thin, the space between plants exceeding the desired 6 inches by 3.9 inches in 1917 and by 2.04 inches in 1918. During the last three years rate 1 has practically averaged one plant to each 6 inches of row space. The plats for rate 3, one plant to each 12 inches, were also too thin in 1917 and 1918, but during the last three years this rate has been very close to one plant to each 12 inches. Rate 5, one plant to each 18 inches, was too thin during 1917 and 1918, but in 1919, 1920, and 1921 it has been close to the 18-inch space desired. Rate 7, one plant to each 24 inches, and rate 9, one plant to each 30 inches, have been close to the desired spacings in each of the five years.

Because of the tendency of Dwarf Yellow milo to produce suckers, the average stalk space is relatively much less for the thin rates than the plant space. The average plant space for rate 1 during the five years was 7.20 inches and that for rate 9 was 29.54 inches, while the average stalk spaces in the same period were 5.14 and 9.39 inches for rates 1 and 9, respectively. Though there are several exceptions, in general the number of suckers per plant increases with the distance between the plants. The maximum number of suckers produced by Dwarf Yellow milo at the Woodward Field Station has been approximately 2.5 suckers per plant. In 1920 and 1921 rate 7, one plant to each 24 inches, produced more suckers per plant than rate 9. During the other years rate 9 produced the greatest number of suckers per plant, as was to be expected.

The percentage of erect heads averaged more than 90 per cent for all spacings in 1918, 1919, and 1920. In 1918 the milo made boot and headed during the dry period early in August. As a result, growth was slow and no pendent heads resulted. In both 1919 and 1920 the thinner rates had slightly more pendent heads than the thicker rates. In 1917 the percentage of erect heads averaged about 50 per cent for the five rates, the large number of pendent heads no doubt being due to the boots and heads forming during and after the period of good rains in the latter part of August. In 1921 the percentage of erect heads was highest in the thickest rate and decreased regularly with the wider spacing. This was due to good moisture and growing conditions at the time of heading.

TABLE 23.—*Data in the spacing experiments with Dwarf Yellow milo grown in rows 44 inches apart at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 58 pounds.]

Year and rate No.	Row space.		Stalks per plant.	Stalks headed.	Erect heads.	Total growing period.	Height.	Grain in total crop.	Yields per acre.		
	Plant.	Stalk.							Total crop.	Grain.	
1917:	*Inches.*	*Inches.*		*Per ct.*	*Per ct.*	*Days.*	*Feet.*	*Per ct.*	*Lbs.*	*Lbs.*	*Bush.*
Rate 1	9.90	6.16	1.61	86.1	48.6	139	3.3	27.0	4,500	1,215	20.9
Rate 3	14.40	6.78	2.12	83.6	51.5	139	3.0	22.6	4,600	1,040	17.9
Rate 5	19.88	7.26	2.74	90.0	50.6	139	4.0	27.2	5,400	1,470	25.3
Rate 7	25.02	7.79	3.23	85.8	52.6	139	3.5	25.7	4,550	1,170	20.2
Rate 9	28.28	8.43	3.36	87.8	46.0	139	3.0	27.2	4,100	1,220	21.0
1918:											
Rate 1	8.04	5.44	1.48	38.6	100.0	96	3.3	6.1	2,325	143	2.5
Rate 3	13.77	7.32	1.88	41.8	100.0	96	3.5	8.3	1,450	120	2.1
Rate 5	22.30	9.34	2.89	75.0	100.0	96	3.5	10.8	2,400	260	4.5
Rate 7	24.82	8.01	3.02	58.0	100.0	96	3.5	9.3	2,050	190	3.3
Rate 9	30.64	9.43	3.25	41.8	100.0	96	3.5	5.5	1,450	80	1.4
1919:											
Rate 1	5.93	5.15	1.15	88.4	99.7	114	4.0	28.3	5,670	1,602	27.6
Rate 3	12.06	6.07	1.99	64.2	99.9	115	3.5	23.1	4,250	980	16.9
Rate 5	18.08	8.69	2.11	76.9	96.7	117	3.3	24.9	3,500	870	15.0
Rate 7	23.92	9.54	2.51	98.0	93.5	125	3.3	33.3	5,250	1,750	30.2
Rate 9	28.96	10.27	2.82	96.1	95.8	125	3.3	30.3	4,450	1,350	23.2
1920:											
Rate 1	6.12	4.40	1.39	76.2	99.6	104	3.9	23.4	6,975	1,629	28.1
Rate 3	12.30	5.18	2.37	87.2	99.5	108	3.7	24.5	6,814	1,671	28.8
Rate 5	18.30	5.35	3.42	92.8	98.8	111	3.8	22.5	9,129	2,057	35.5
Rate 7	24.18	6.93	3.65	96.4	94.9	111	4.0	27.4	7,971	2,186	37.7
Rate 9	29.61	8.90	3.33	95.5	96.1	111	3.6	26.8	7,393	1,980	34.1
1921:											
Rate 1	6.00	4.55	1.32	91.5	95.9	106	4.8	32.6	7,290	2,376	41.0
Rate 3	12.03	4.92	2.44	93.9	69.9	109	5.0	38.2	7,843	2,996	51.6
Rate 5	18.00	6.14	2.93	97.8	57.8	109	5.0	40.7	7,329	2,983	51.4
Rate 7	23.97	7.56	3.17	98.3	51.0	109	4.5	44.7	6,236	2,790	48.1
Rate 9	30.23	9.90	3.06	98.9	44.2	109	4.3	44.3	5,657	2,533	43.7
5-year average, 1917 to 1921:											
Rate 1	7.20	5.14	1.39	76.2	88.8	112	3.9	23.5	5,352	1,393	24.0
Rate 3	12.91	6.05	2.16	74.1	84.2	113	3.7	23.3	4,991	1,361	23.5
Rate 5	19.31	7.36	2.82	86.5	80.8	114	3.9	25.2	5,552	1,528	26.3
Rate 7	24.38	7.97	3.11	87.3	78.4	116	3.8	28.1	5,211	1,617	27.9
Rate 9	29.54	9.39	3.16	84.0	76.4	116	3.5	26.8	4,610	1,433	24.7

The percentage of grain in the total crop and the yields in both pounds and bushels to the acre are given in Table 23. In grain yields the different rates have varied greatly in any one year and even more between years. In 1917 and 1918 rate 5, one plant to each 18 inches, made the highest grain yield for the 44-inch rows. In 1919 and 1920 rate 7, one plant to each 24 inches, made the highest grain yield, while in 1921 rates 3 and 5 made the highest yields.

Table 24 shows the annual and average acre yields from the different rates of Dwarf Yellow milo in rows spaced 44 inches apart during the 5-year period from 1917 to 1921, inclusive. In this table the extreme row space per plant for the five years is indicated. As noted, no one rate of spacing has given the highest yields in each of the five years. The best spacing between plants in the row must be determined from the average yield for the period. Rate 7, one plant each 24 inches, made the highest average grain yield for the five years, 27.9 bushels to the acre. The next highest yield, 26.3 bushels, was produced from what was intended to be the 18-inch spacing, but which actually varied from 18 to 22 inches. The lowest average grain yield was made by rate 3, one plant each 12 inches, with a 5-year average of 23.5 bushels to the acre. The 6-inch and 30-inch spacings yielded

slightly better than the 12-inch ones. With differences in distance between plants varying from 6 to 30 inches by 6-inch steps, the difference in the average yield between the spacings producing the highest and the lowest yields was but 4.4 bushels per acre per year. The difference between the high-yielding and the low-yielding rates for the individual years shows the following: 1917, 7.4 bushels; 1918, 3.1 bushels; 1919, 15.2 bushels; 1920, 9.6 bushels; and 1921, 10.6 bushels. These differences between the yields of the rates in the individual years are large and significant and are due to climatic conditions affecting the various rates differently. Considering the 5-year average, a spacing of one plant to each 18 to 25 inches is to be desired, though a thicker or even a thinner stand should not be destroyed or lead the grower to resow.

TABLE 24.—*Yields of Dwarf Yellow milo in rows 44 inches apart in the spacing experiments at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

Row space per plant.	Rate No.	Yields per acre (58-pound bushels).					
		1917	1918	1919	1920	1921	Average.
6 to 9.9 inches	1	20.9	2.5	27.6	28.1	41.0	24.0
12 to 14.4 inches	3	17.9	2.1	16.9	28.8	51.6	23.5
18 to 22.3 inches	5	25.3	4.5	15.0	25.5	51.4	26.3
24 to 25 inches	7	20.2	3.3	30.2	37.7	48.1	27.9
28 to 30 inches	9	21.0	1.4	23.2	34.1	43.7	24.7

SECOND DIVISION, ROWS 88 INCHES APART.

The second division of these experiments differs from the first in that the rows are 88 inches, or twice the distance, apart, and the plants are twice as thick in the rows, giving the same number of plants to the unit area as in the corresponding plats in the first division.

Table 25 shows the data for Dwarf Yellow milo grown in rows spaced 88 inches apart in the spacing experiments during the 5-year period from 1917 to 1921, inclusive. In 1917 and 1918 the three thicker rates were thinner than was desired, but during the last three years the actual spacings between plants have been close to the desired spacings. The two thinner rates in 1917 and 1918 were also approximately as desired.

The tendency of milo in thin stands to produce suckers is as apparent when the rows are 88 inches apart as when the rows are but 44 inches apart. The row space per plant for rate 2 averaged 3.62 inches, while that for rate 10 averaged 14.68 inches. The average stalk space, however, was 3.24 and 5.78 inches for rates 2 and 10, respectively. As in division 1, the 44-inch rows, the number of suckers per plant increased with the distance between the plants.

The percentage of erect heads varied from 100 per cent for all except the thinnest rate in 1918 to less than 40 per cent for certain of the thinner rates in 1917 and 1921. As a general average, the milo in 88-inch rows had a lower percentage of erect heads than the corresponding plats in 44-inch rows. This may be due to more vigorous growth at heading time of the plants in rows 88 inches apart than of the plants in 44-inch rows.

TABLE 25.—*Data in the spacing experiments with Dwarf Yellow milo grown in rows 88 inches apart at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 58 pounds.]

Year and rate No.	Row space.		Stalks per plant.	Stalks headed.	Erect heads.	Total growing period.	Height.	Grain in total crop.	Yields per acre.	
	Plant.	Stalk.							Total crop.	Grain.
1917:	*Ins.*	*Ins.*		*Per ct.*	*Per ct.*	*Days.*	*Feet.*	*Per ct.*	*Lbs.*	*Lbs.*	*Bush.*
Rate 2	4.98	4.03	1.24	91.2	44.9	139	3.5	22.2	3,769	838	14.4
Rate 4	7.20	4.77	1.51	88.3	50.8	139	3.5	21.5	3,656	788	13.6
Rate 6	10.22	4.92	2.08	92.0	45.2	139	3.8	28.4	3,600	1,024	17.7
Rate 8	12.51	5.00	2.51	91.3	38.1	139	3.8	25.1	3,431	872	15.0
Rate 10	14.14	4.96	2.85	90.0	37.9	139	3.5	27.2	3,870	1,053	18.2
1918:											
Rate 2	4.02	3.67	1.10	51.1	100.0	96	2.8	15.0	1,238	186	3.2
Rate 4	8.14	5.03	1.62	81.3	100.0	96	3.0	30.0	1,744	523	9.0
Rate 6	11.48	5.85	1.96	86.5	100.0	96	3.0	14.2	2,138	304	5.2
Rate 8	12.28	5.99	2.05	70.4	100.0	96	3.0	15.2	1,725	263	4.5
Rate 10	15.48	5.47	2.83	63.2	99.8	96	2.8	12.7	1,650	210	3.6
1919:											
Rate 2	3.04	2.92	1.04	91.1	99.9	114	4.3	31.5	5,006	1,575	27.2
Rate 4	5.79	4.74	1.22	87.7	99.1	115	4.5	37.1	3,150	1,170	20.2
Rate 6	8.97	6.80	1.32	96.1	84.6	117	3.8	39.1	3,600	1,406	24.2
Rate 8	11.61	6.54	1.78	98.8	81.4	125	3.8	36.5	4,500	1,643	28.3
Rate 10	14.19	7.17	1.98	96.2	92.1	125	3.5	35.3	3,240	1,143	19.7
1920:											
Rate 2	3.06	2.65	1.16	91.9	99.7	99	4.5	27.1	6,300	1,710	29.5
Rate 4	6.05	3.11	1.95	94.0	97.3	108	4.3	31.2	6,356	1,980	34.1
Rate 6	9.19	3.21	2.74	94.8	95.4	108	4.4	33.7	6,244	2,104	36.3
Rate 8	12.32	3.90	3.14	98.0	85.7	108	4.6	34.3	6,469	2,216	38.2
Rate 10	14.50	4.66	3.11	95.6	95.3	111	4.3	33.6	6,300	2,115	36.5
1921:											
Rate 2	3.00	2.91	1.03	96.8	93.8	106	5.7	35.9	6,806	2,441	42.1
Rate 4	6.03	3.75	1.61	97.0	51.4	109	5.6	40.2	6,919	2,779	47.9
Rate 6	9.00	4.57	1.97	99.1	45.4	109	5.2	41.4	6,356	3,633	45.4
Rate 8	12.00	4.78	2.51	98.6	34.8	109	5.2	42.9	6,188	2,655	45.8
Rate 10	15.08	6.66	2.26	98.9	48.4	109	4.8	48.0	4,815	2,313	39.9
5-year average, 1917 to 1921:											
Rate 2	3.62	3.24	1.11	84.4	87.7	111	4.2	26.3	4,624	1,350	23.3
Rate 4	6.64	4.28	1.58	89.7	79.7	113	4.2	32.0	4,365	1,448	25.0
Rate 6	9.77	5.07	2.01	93.7	74.1	114	4.0	31.4	4,388	1,694	25.8
Rate 8	12.14	5.24	2.40	91.4	68.0	115	4.1	30.8	4,463	1,530	26.4
Rate 10	14.68	5.78	2.61	88.8	74.7	116	3.8	31.4	3,975	1,367	23.6

The same correlation between stalks producing heads and yield of grain is apparent in the 88-inch as in the 44-inch rows.

The total crop yield varied from 6,919 pounds for the rate with plants spaced 6 inches apart in 1921 to 1,238 pounds for the rate with plants spaced 4 inches apart in 1918. These extreme yields of total crop also produced the highest and the lowest grain yields, respectively, though this correlation does not obtain throughout the years and rates. The yields of total crop and grain are shown in Table 25. The annual and average grain yields for the different rates of spacing plants for the five years are given in Table 26 for convenient comparison.

In Table 26 the extreme row space per plant for the five spacings of Dwarf Yellow milo in rows 88 inches apart is indicated for the 5-year period from 1917 to 1921, inclusive. No one spacing gave the highest yield for more than two of the five years. In 1917 the thinnest rate, one plant each 14 inches, made the best grain yield. In 1918 and 1921 the high grain yields were produced from plats with the plants spaced 6 inches apart in the row, while in 1919 and 1920 the high yields were from the 12-inch spacings. The average yields from the different spacings show little variation for the 5-year period, ranging only between 23.3 and 26.4 bushels. The highest yield was

produced from rows with plants 12 inches apart in the row, the 9-inch spacing ranking second, with an average of 25.8 bushels to the acre. The lowest average yield was obtained from the thickest rate. For dwarf milo in rows 88 inches apart the best distance between plants appears to be from 9 to 12 inches.

TABLE 26.—*Yields of Dwarf Yellow milo in rows 88 inches apart in the spacing experiments at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

Row space per plant.	Rate No.	Yields per acre (58-pound bushels).					
		1917	1918	1919	1920	1921	Average.
3 to 5 inches	2	14.4	3.2	27.2	29.5	42.1	23.3
6 to 7 inches	4	13.6	9.0	20.2	34.1	47.9	25.0
9 to 11 inches	6	17.7	5.2	24.2	36.3	45.4	25.8
12 inches	8	15.0	4.5	28.3	38.2	45.8	26.4
14 to 15 inches	10	18.2	3.6	19.7	36.5	39.9	23.6

COMPARATIVE YIELDS FROM 44-INCH AND 88-INCH ROWS.

Table 27 shows the annual and average acre yields of Dwarf Yellow milo in the spacing experiments, arranged so that direct comparisons may be made readily between the rows spaced 44 inches and 88 inches apart, containing approximately the same number of plants to the acre. The spacings are arranged in five groups, each showing the yields from one set of rows spaced 44 inches and one spaced 88 inches apart, the space between plants in the row in the latter being half that in the former. The data given are the distances between rows in inches, the approximate row space between plants, and the annual and average acre yields for each spacing.

TABLE 27.—*Yields of Dwarf Yellow milo in the spacing experiments at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

Group and approximate number of plants per acre.	Space (inches) between—		Yield per acre (58-pound bushels).					
	Rows.	Plants in the row.	1917	1918	1919	1920	1921	Average.
Group A, 20,000 plants	44	7.2	20.9	2.5	27.6	28.1	41.0	24.0
	88	3.6	14.4	3.2	27.2	29.5	42.1	23.3
Group B, 11,000 plants	44	13.0	17.9	2.1	16.9	28.8	51.6	23.5
	88	6.6	13.6	9.0	20.2	34.1	47.9	25.0
Group C, 7,400 plants	44	19.3	25.3	4.5	15.0	35.5	51.4	26.3
	88	9.8	17.7	5.2	24.2	36.3	45.4	25.8
Group D, 5,900 plants	44	24.4	20.2	3.3	30.2	37.7	48.1	27.9
	88	12.1	15.0	4.5	28.3	38.2	45.8	26.4
Group E, 4,800 plants	44	29.5	21.0	1.4	23.2	34.1	43.7	24.7
	88	14.7	18.2	3.6	19.7	36.5	39.9	23.6

Group A shows the data for the thick rate, with an average of approximately one plant to 7.2 inches of row space in rows 44 inches apart and of one plant to each 3.6 inches in rows 88 inches apart, or

about 20,000 plants to the acre. The highest yield, 42.1 bushels, from this rate was made in 1921 from rows spaced 88 inches apart and the lowest yield, 2.5 bushels, from rows 44 inches apart in 1918. The 5-year average yields for this rate are 0.7 bushel in favor of the 44-inch rows. The plats grown in 1921 from this rate in 44-inch and in 88-inch rows are shown in Plate VI.

Group B represents an average stand of one plant to each 13 inches of row space for the rows 44 inches apart and one to each 6.6 inches for the 88-inch rows, or approximately 11,000 plants to the acre. The 44-inch rows outyielded the 88-inch rows in but two of the five years, 1917 and 1921, and the 5-year average yield is 1.5 bushels in favor of the 88-inch rows. This is the only one of the five different rates that gave a higher 5-year average yield for the rows spaced 88 inches apart than for the corresponding stand in 44-inch rows. This spacing in 44-inch rows, 12 to 14 inches between plants, gave the lowest 5-year average yield for rows spaced this distance apart, in spite of the high yield made from this spacing in 1921. The comparatively low yield from this spacing is associated with a low percentage of stalks producing heads, which was especially noticeable in 1917 and 1919. Observations in the plats showed that the plants at this spacing had a tendency to produce one to two suckers to the plant and that these suckers ordinarily were unable to produce good heads. In the thinner rates the suckers generally produced as good heads as the main stalk, while in the thicker rate (one plant to each 7.2 inches) there were few suckers and the main stalk generally produced a fair head.

Group C, with an average stand of one plant to each 19.3 inches in the rows spaced 44 inches apart and one plant to each 9.8 inches in the 88-inch rows, averaged approximately 7,400 plants to the acre. In 1918, 1919, and 1920 the 88-inch rows outyielded the 44-inch rows, but the 5-year average yield is in favor of the 44-inch rows by 0.5 bushel. This spacing produced the second highest average yields from both the 44-inch and 88-inch rows.

Group D averaged one plant to each 24.4 inches of row space in the rows 44 inches apart and one plant to each 12.1 inches in the rows 88 inches apart, or approximately 5,900 plants to the acre. In this rate the rows 88 inches apart made higher grain yields in 1918 and 1920 than the rows 44 inches apart, but the 5-year average yield is 1.5 bushels per acre in favor of the rows 44 inches apart. This spacing, approximately 6,000 plants per acre, made the highest 5-year average yield in both the 44-inch and 88-inch rows, indicating that it is near to the best spacing for Dwarf Yellow milo under the conditions at the Woodward Field Station.

Group E is the thinnest rate tried. An average of one plant to each 29.5 inches of row space in rows 44 inches apart and of one plant to each 14.7 inches in rows 88 inches apart was obtained, approximating 4,800 plants to the acre. In three of the five years the 44-inch rows outyielded the 88-inch rows, and the 5-year average yield from the 44-inch rows is higher by 1.1 bushels per acre. This spacing of the plants, 30 inches and 15 inches in rows 44 and 88 inches apart, respectively, is slightly too thin to enable Dwarf Yellow milo to return maximum yields under the conditions prevailing at the Woodward Field Station.

These data indicate that Dwarf Yellow milo is a very adaptable crop, giving an extreme difference of only 4.6 bushels in the average acre yield in the five years from stands varying from 20,000 to 4,800 plants per acre spaced in rows 44 inches and 88 inches apart. In 1918, an unfavorable year, milo in 88-inch rows outyielded that in 44-inch rows, and again in 1920 the 88-inch rows were slightly better. In average yields for the 5-year period the 44-inch rows lead except where the plants were spaced 13 inches apart, or approximately 11,000 plants to the acre. The best spacing is one plant to each 18 to 24 inches in rows 44 inches apart or one to each 9 to 12 inches in 88-inch rows. These rates approximate 6,000 to 8,000 plants to the acre. There appears to be a slight disadvantage rather than advantage in growing milo in 88-inch rather than in 44-inch rows.

SUNRISE KAFIR.

The spacing experiments conducted with Dwarf Yellow milo were duplicated with Sunrise kafir. The object and nature of these experiments have already been explained; hence only the results need be considered here. The data for the spacing experiments with Sunrise kafir are given in Tables 28 to 32, inclusive.

TABLE 28.—*Data in the spacing experiments with Sunrise kafir grown in rows 44 inches apart at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

[In the statement of yield of grain per acre, the bushel is rated at 60 pounds.]

Year and rate No.	Row space.		Stalks per plant.	Stalks headed.	Total growing period.	Height.	Grain in crop.	Yields per acre.		
	Plant.	Stalk.						Total crop.	Grain.	
1917:	*Inches.*	*Inches.*		*Per ct.*	*Days.*	*Feet.*	*Per ct.*	*Pounds.*	*Pounds.*	*Bushels.*
Rate 1	7.21	4.14	1.74	94.2	143	6.3	18.8	9,338	1,755	29.2
Rate 3	13.09	4.95	2.94	95.6	143	6.0	18.5	9,350	1,730	28.8
Rate 5	18.40	5.04	3.65	96.3	143	6.3	20.5	8,800	1,800	30.0
Rate 7	24.52	5.95	4.12	97.4	143	6.0	20.2	8,350	1,690	28.2
Rate 9	28.80	6.66	4.32	96.3	143	6.0	22.0	7,350	1,620	27.0
1918:										
Rate 1	8.90	6.82	1.31	61.4	109	4.5	12.2	3,825	467	7.8
Rate 3	12.48	7.74	1.62	66.5	109	4.3	14.5	4,000	580	9.7
Rate 5	17.80	7.32	2.43	61.1	109	4.3	11.7	4,350	510	8.5
Rate 7	23.58	7.62	3.11	74.4	109	4.3	14.4	4,450	640	10.7
Rate 9	29.34	10.96	2.68	84.8	109	4.5	15.8	4,000	630	10.5
1919:										
Rate 1	6.05	4.86	1.24	85.8	107	5.5	29.6	5,445	1,557	26.0
Rate 3	11.76	6.36	1.85	78.4	107	5.5	32.9	5,050	1,660	27.7
Rate 5	15.96	8.74	1.82	88.9	110	5.0	35.2	4,200	1,480	24.7
Rate 7	23.50	8.08	2.91	91.5	110	5.3	31.1	5,050	1,570	26.2
Rate 9	29.88	9.08	3.29	96.8	110	5.5	34.1	5,450	1,970	32.8
1920:										
Rate 1	5.94	4.07	1.46	84.2	106	5.8	30.6	6,300	1,923	32.1
Rate 3	12.03	4.42	2.72	87.1	108	5.5	29.7	6,878	2,044	34.1
Rate 5	17.92	5.07	3.54	92.7	108	5.7	31.6	6,428	2,031	33.9
Rate 7	23.29	6.22	3.75	96.1	108	5.7	35.6	5,978	2,128	35.5
Rate 9	29.12	7.31	3.99	98.3	108	5.9	36.2	5,593	2,025	33.8
1921:										
Rate 1	6.10	4.99	1.22	91.8	109	6.6	34.1	6,705	2,286	38.1
Rate 3	12.00	5.92	2.03	89.1	111	6.8	31.5	7,136	2,250	37.5
Rate 5	18.00	6.95	2.59	96.1	113	6.5	34.6	6,364	2,205	35.8
Rate 7	24.52	10.67	2.31	98.0	113	6.3	33.3	5,657	1,884	31.4
Rate 9	30.00	12.84	2.34	97.1	113	6.2	35.0	4,693	1,691	28.2
5-year average, 1917 to 1921:										
Rate 1	6.84	4.98	1.40	83.5	115	5.7	25.1	6,323	1,598	26.6
Rate 3	12.27	5.88	2.23	83.3	116	5.6	25.4	6,483	1,653	27.6
Rate 5	17.62	6.62	2.80	87.0	117	5.6	25.7	6,028	1,605	26.8
Rate 7	23.88	7.71	3.24	91.5	117	5.5	26.9	5,897	1,582	26.4
Rate 9	29.43	9.37	3.32	94.7	117	5.6	28.8	5,417	1,587	26.5

FIRST DIVISION, ROWS 44 INCHES APART.

The data for Sunrise kafir in the spacing experiments with rows 44 inches apart are shown in Table 28. Five plats were grown each year, representing five different rates. The desired spacings for the different rates were one plant to each 6, 12, 18, 24, and 30 inches in the row. As indicated by the row space per plant, comparable stands were obtained in different years for all rates of spacing except the thick rates in 1917 and 1918, when the row space exceeded the desired spacing by 1.2 and 2.9 inches, respectively.

The tendency in Sunrise kafir to produce suckers is as great as or greater than in Dwarf Yellow milo. The greatest number of suckers per plant in Sunrise kafir in these experiments was in 1917 in the thinnest plat, which averaged 3.32 suckers for each plant. The minimum number of suckers produced in these experiments was in 1921, when the thick plat averaged 0.22 sucker per plant. As was the case with Dwarf Yellow milo, the number of suckers generally increases with the row space between plants.

The percentage of headed stalks varies considerably between rates for any single year, but the relation between stalks headed and grain yield is not as apparent as in similar studies with Dwarf Yellow milo.

The total crop yields have varied from 9,350 pounds per acre for rate 3 (12 inches) in 1917 to 3,825 pounds per acre for rate 1 (6 inches) in 1918. Total crop yield and grain yield do not show close correlation in the spacing experiments with Sunrise kafir. This is indicated by the data on the percentage of grain in the total crop, which varies greatly in different years and considerably as between rates in the same year. Table 29 shows the annual and average grain yields from the five plant spacings with Sunrise kafir in rows 44 inches apart.

TABLE 29.—*Yields of Sunrise kafir in rows 44 inches apart in the spacing experiments at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

Row space per plant.	Rate No.	Yields per acre (60-pound bushels).					
		1917	1918	1919	1920	1921	Average.
6 to 8.9 inches	1	29.2	7.8	26.0	32.1	38.1	26.6
12 to 13 inches	3	28.8	9.7	27.7	34.1	37.5	27.6
16 to 18 inches	5	30.0	8.5	24.7	33.9	36.8	26.8
23 to 24.5 inches	7	28.2	10.7	26.2	35.5	31.4	26.4
29 to 30 inches	9	27.0	10.5	32.8	33.8	28.2	26.5

It is readily noted from Table 29 that the 5-year averages for the five rates vary but little. The highest 5-year average, 27.6 bushels per acre, was obtained from rate 3, one plant to each 12 to 13 inches, and the lowest average yield, 26.4 bushels, from rate 7, one plant to each 24 inches of row space. The difference in yields between extremes was but 1.2 bushels per acre, or less than 5 per cent. One interesting fact is that rate 3 made the highest 5-year average yield, yet in the five years it never made the highest yield in any one year. From these results no particular spacing can be recommended for Sunrise kafir, though a spacing of one plant to every 12 inches will give maximum returns of grain and total crop during a period of

FIG. 1.—PLAT OF SUNRISE KAFIR IN ROWS 44 INCHES APART.

The plants in this plat were spaced 30 inches apart in the rows. The yield was 28.2 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

FIG. 2.—PLAT OF SUNRISE KAFIR IN ROWS 88 INCHES APART.

The plants in this plat were spaced 15 inches apart in the rows. The yield was 24.5 bushels per acre. Photographed at the Woodward Field Station, September 6, 1921.

years. One fact to be emphasized is that Sunrise kafir has a tendency to produce many suckers when the stand is thin, and this character is doubtless the reason why the difference between the yields from the different rates is so slight.

SECOND DIVISION, ROWS 88 INCHES APART.

Table 30 gives the data obtained from Sunrise kafir in rows 88 inches apart in the spacing experiments. Five plats were grown each year, each plat representing a different rate. With the exception of the thick rate in 1918, the desired stands were approximated in the different rates for the five years.

TABLE 30.—*Data in the spacing experiments with Sunrise kafir grown in rows 88 inches apart at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

[In the statement of yields of grain per acre the bushel is rated at 60 pounds.]

Year and rate No.	Row space.		Stalks per plant.	Stalks headed.	Total growing period.	Height.	Grain in total crop.	Yields per acre.		
	Plant.	Stalk.						Total crop.	Grain.	
1917:	*Inches.*	*Inches.*		*Per ct.*	*Days.*	*Feet.*	*Per ct.*	*Pounds.*	*Pounds.*	*Bushels.*
Rate 2	3.61	2.83	1.27	94.5	143	6.3	20.2	5,906	1,193	19.9
Rate 4	6.87	3.38	2.03	95.0	143	6.3	22.5	6,000	1,350	22.5
Rate 6	9.46	3.40	2.78	95.7	143	6.3	23.5	5,738	1,350	22.5
Rate 8	13.05	3.85	3.39	97.1	143	6.0	22.5	5,794	1,305	21.8
Rate 10	14.27	4.03	3.55	97.1	143	6.0	21.5	5,490	1,179	19.7
1918:										
Rate 2	4.45	3.86	1.15	82.1	106	4.8	17.6	3,750	660	11.0
Rate 4	6.15	4.59	1.34	87.4	106	4.5	17.4	3,825	664	11.1
Rate 6	8.82	5.21	1.69	85.4	109	4.8	16.4	3,150	518	8.6
Rate 8	11.79	5.57	2.12	94.2	109	4.8	19.0	4,050	771	12.8
Rate 10	14.67	6.35	2.31	94.4	109	4.8	22.0	3,431	754	12.6
1919:										
Rate 2	2.89	2.46	1.17	86.5	107	6.0	28.7	5,288	1,519	25.3
Rate 4	5.34	4.17	1.28	90.0	108	5.5	34.0	3,938	1,339	22.3
Rate 6	9.18	6.08	1.51	92.1	110	5.5	32.8	3,600	1,181	19.7
Rate 8	11.61	5.20	2.23	91.6	110	5.5	42.7	3,375	1,440	24.0
Rate 10	14.87	6.37	2.33	95.7	110	5.8	37.6	3,690	1,386	23.1
1920:										
Rate 2	3.18	2.62	1.21	90.9	105	5.8	32.4	4,894	1,586	26.4
Rate 4	5.95	3.03	1.97	91.9	108	6.0	36.8	4,950	1,823	30.4
Rate 6	9.04	3.37	2.69	94.7	108	6.0	37.0	4,894	1,811	30.2
Rate 8	12.21	3.68	3.32	95.4	108	6.1	37.2	4,894	1,823	30.4
Rate 10	15.20	4.08	3.72	97.2	108	6.2	35.6	4,838	1,721	28.7
1921:										
Rate 2	3.18	2.87	1.11	90.7	111	6.8	32.5	5,569	1,811	30.2
Rate 4	6.00	4.29	1.40	95.2	111	6.9	31.6	5,906	1,868	31.1
Rate 6	9.00	4.77	1.89	95.6	113	6.9	36.8	4,894	1,800	30.0
Rate 8	12.71	7.22	1.76	97.5	113	6.2	34.7	4,219	1,463	24.4
Rate 10	15.03	7.23	2.08	97.6	113	6.3	37.4	3,780	1,467	24.5
5-year average, 1917 to 1921:										
Rate 2	3.46	2.93	1.18	88.9	114	5.9	26.3	5,081	1,354	22.6
Rate 4	6.06	3.89	1.60	91.9	115	5.8	28.5	4,924	1,409	23.5
Rate 6	9.10	4.57	2.11	92.7	117	5.9	29.3	4,455	1,332	22.2
Rate 8	12.27	5.10	2.57	95.2	117	5.7	31.2	4,466	1,360	22.7
Rate 10	14.81	5.61	2.80	96.4	117	5.8	30.8	4,246	1,301	21.7

The number of suckers for each plant increased with the row space per plant, as in the rows 44 inches apart. The average number of suckers to the plant varied from 0.11 for the thick spacing (rate 2) in 1921 to 2.55 suckers per plant for the thin spacing (rate 10) in 1917. One fact to be noted is that with the same number of plants to the acre the plants in the rows 44 inches apart average more suckers per plant than those in the rows 88 inches apart. On the other hand, where the spacing between plants in the rows is the same

(plants 6 inches apart in rate 1, rows 44 inches apart, and in rate 4, rows 88 inches apart, and plants 12 inches apart in rate 3, rows 44 inches apart, and in rate 8, rows 88 inches apart) the plants in rows 88 inches apart produce more suckers than the plants in rows 44 inches apart. These facts indicate that under similar conditions the distance between plants in the row influences suckering more than the distance between rows, though the distance between rows influences suckering to a slight extent.

The rates in rows 88 inches apart have produced a higher average percentage of headed stalks than the rates in rows 44 inches apart. This tendency was especially noticeable in 1918, a poor season for sorghums.

The total crop yields for the 88-inch rows are not as high as those for the corresponding rates in rows 44 inches apart. This is one fact to be considered in Sunrise kafir, which is a combination grain and forage crop. There is a closer correlation between the total crop and the grain yields in the Sunrise kafir rates in rows 88 inches apart than in any other division of the spacing experiments.

Table 31 shows the annual and average acre yields in bushels of 60 pounds from the five spacings of Sunrise kafir in rows 88 inches apart for the five years from 1917 to 1921, inclusive. Considering the 5-year average yield, rate 4, one plant to 5.3 to 6.8 inches of row space, has the highest average, with 23.5 bushels per acre. This rate of spacing plants in the row made the highest yield in 1921 and as high a yield as any of the other rates in 1917 and 1920. The lowest average yield was 21.7 bushels, produced by rate 10, the thin spacing, which averaged one plant to each 15 inches of row space. This gives an annual difference of 1.8 bushels per acre between the highest and the lowest yielding spacings of Sunrise kafir in rows 88 inches apart.

TABLE 31.—*Yields of Sunrise kafir in rows 88 inches apart in the spacing experiments at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

Row space per plant.	Rate No.	Yields per acre (60-pound bushels).					
		1917	1918	1919	1920	1921	Average.
2.9 to 4.5 inches	2	19.9	11.0	25.3	26.4	30.2	22.6
5.3 to 6.8 inches	4	22.5	11.1	22.3	30.4	31.1	23.5
8.8 to 9.5 inches	6	22.5	8.6	19.7	30.2	30.0	22.2
11.6 to 13 inches	8	21.8	12.8	24.0	30.4	24.4	22.7
14.3 to 15.2 inches	10	19.7	12.6	23.1	28.7	24.5	21.7

COMPARATIVE YIELDS FROM 44-INCH AND 88-INCH ROWS.

Table 32 shows the annual and average acre yields of Sunrise kafir in rows 44 inches and 88 inches apart in the spacing experiments. This table permits easy comparison between the yields obtained from the different spacings of plants and rows.

Group A, the thick rate of plant spacing in the row, averages 6.8 inches of row space to the plant in the rows 44 inches apart and 3.5 inches of row space per plant in the rows 88 inches apart, or approximately 21,000 plants to the acre. At this spacing the ordinary rows, 44 inches apart, have outyielded the wide rows, 88 inches apart, by an annual average of 4 bushels per acre for the five years.

TABLE 32.—*Yields of Sunrise kafir in the spacing experiments at the Woodward Field Station during the 5-year period from 1917 to 1921, inclusive.*

Group and approximate number of of plants per acre.	Space (inches) between—		Yield per acre (60-pound bushels).					
	Rows.	Plants in the row.	1917	1918	1919	1920	1921	Average.
Group A, 21,000 plants	44	6.8	29.2	7.8	26.0	32.1	38.1	26.6
	88	3.5	19.9	11.0	25.3	26.4	30.2	22.6
Group B, 11,000 plants	44	12.3	28.8	9.7	27.7	34.1	37.5	27.6
	88	6.1	22.5	11.1	22.3	30.4	31.1	23.5
Group C, 8,000 plants	44	17.6	30.0	8.5	24.7	33.9	36.8	26.8
	88	9.1	22.5	8.6	19.7	30.2	30.0	22.2
Group D, 5,900 plants	44	23.9	28.2	10.7	26.2	35.5	31.4	26.4
	88	12.3	21.8	12.8	24.0	30.4	24.4	22.7
Group E, 4,800 plants	44	29.4	27.0	10.5	32.8	33.8	28.2	26.5
	88	14.8	19.7	12.6	23.1	28.7	24.5	21.7

Group B has a stand of one plant to each 11.8 to 13.1 inches in rows 44 inches apart and one to each 5.3 to 6.9 inches in rows 88 inches apart, or approximately 11,000 plants to the acre. It is interesting to note that this spacing has made the highest average grain yields in both the 44-inch and the 88-inch rows. The rows 44 inches apart have averaged 4.1 bushels per acre a year more than the rows spaced 88 inches apart.

Group C represents a rate of one plant to each 16 to 18.4 inches of row space in the 44-inch rows, or one to each 8.8 to 9.5 inches in the 88-inch rows, approximately 8,000 plants to the acre. In the five years the 44-inch rows have averaged 4.6 bushels per acre a year more than the 88-inch rows.

Group D has had a stand of one plant to each 23.5 to 24.5 inches in the 44-inch rows and one plant to each 11.6 to 13 inches in the rows 88 inches apart, or approximately 5,900 plants to the acre. At this spacing the 44-inch rows have averaged 3.7 bushels per acre a year more than the 88-inch rows.

Group E is the thin rate of spacing. It has averaged one plant to 29.4 inches of row space in the 44-inch rows and one to each 14.8 inches in the 88-inch rows, or approximately 4,800 plants to the acre. The plats grown in 1921 at these spacings are shown in Plate VII. The 44-inch row plats have outyielded the 88-inch row plats by an average of 4.8 bushels per acre a year in the five years.

These data show that the wide-spaced rows, 88 inches apart, have outyielded the rows spaced 44 inches apart in but one year, 1918, and in that year the difference was only from 0.1 to 3.2 bushels per acre in the different rates in favor of the 88-inch rows. The 44-inch rows have exceeded the 88-inch rows in average yield during the 5-year period by from 4.8 to 3.7 bushels for the various stands. Considering grain yield alone, the 88-inch rows are not to be recommended for Sunrise kafir under the conditions at the Woodward Field Station. The best rate for Sunrise kafir is approximately one plant to each 12 inches of row space in 44-inch rows. The extreme difference obtained in spacing plants from 6 to 30 inches apart in

44-inch rows has averaged but 1.2 bushels per acre annually for the 5-year period, while the extreme difference in yield between the various plant spacings in 88-inch rows has been only 1.6 bushels.

SUMMARY.

Cooperative experiments with grain sorghums have been conducted at the Woodward Field Station since 1914. Results obtained during the 8-year period from 1914 to 1921, inclusive, are reported in this bulletin.

The average annual precipitation at Woodward, Okla., is approximately 24 inches. During the 8-year period under consideration the extremes in annual rainfall were 13.68 inches in 1914 and 35.78 inches in 1915. On the average, 70 per cent of the annual precipitation occurs during the six months from April to September, inclusive. This distribution of rainfall is favorable for the production of annual summer-growing crops, such as the sorghums.

Low yields of sorghums are due to periods of drought in July and August rather than to an annual or seasonal deficiency of rainfall.

Varietal experiments with representative varieties of grain sorghums have been conducted during the eight years. Results for this full period are reported for 15 varieties or selections of grain sorghums. A number of other varieties have been grown for shorter periods.

Five varieties or strains of the durra-milo group have been grown during the 8-year period. The average acre yields of these strains are: Standard Yellow milo, 22.8 bushels; Standard White milo, 19.7 bushels; two selections of Dwarf Yellow milo (C. I. Nos. 332 and 359), 21.2 and 21.8 bushels, respectively; and feterita, 21.6 bushels. Though the Standard Yellow milo produced an average of 1.6 bushels and 1 bushel per acre more than the two Dwarf Yellow milos, the latter are to be preferred for grain production, as their shorter stalks permit easier and more economical harvesting.

Of the kafir group, six varieties or strains have been continued during the entire eight years. These varieties, with their 8-year average yields, are: Blackhull kafir, 16.8 bushels; Dawn kafir, 23.8 bushels; Sunrise kafir, 26.3 bushels; White kafir (C. I. No. 370), 17.5 bushels; White African kafir, 19.9 bushels; and Red kafir, 20.8 bushels. Sunrise is a midearly, tall, blackhulled kafir, and in the varietal experiments has produced higher average yields of grain and total crop than any other variety. In grain yield Dawn kafir ranks second to Sunrise.

Three varieties of kaoliang have been grown during the eight years. Their average grain yields are: Blackhull, 18.7 bushels; Manchu, 13.4 bushels; and Valley, 15.9 bushels. The Blackhull kaoliang is the only grain sorghum tested in these experiments that has yielded more than 10 bushels of grain in each of the eight years.

Shallu during the eight years has averaged 15.4 bushels of grain to the acre.

Darso, Schrock sorghum, and Dwarf hegari have been grown in the varietal experiments for less than eight years.

In the varietal experiments, which have been seeded as near the middle of May as conditions permitted, Sunrise and Dawn kafirs have produced the highest yields of grain.

Date-of-seeding experiments with Dwarf Yellow milo and Sunrise kafir have been conducted for five years, 1917 to 1921, inclusive. The two varieties have been seeded each year on six different dates, representing the middle of April, the first and middle of May, the first and middle of June, and the first of July.

The 5-year average yields indicate that Dwarf Yellow milo should be seeded in June. The mid-June seeding made the highest average yield, 33.4 bushels per acre; the June 1 seeding ranked second, with 29.1 bushels; and that made on July 1 third with 28.6 bushels per acre. The mid-May seeding averaged 22.7 bushels per acre.

Sunrise kafir made its highest average yield from the mid-May seeding, with 27 bushels per acre, the June 1 seeding ranking second with an average of 24.7 bushels per acre.

Dawn kafir, feterita, and Blackhull kaoliang have been included in the date-of-seeding experiments for the three years 1919 to 1921, inclusive.

The date-of-seeding experiments show that Dwarf milo seeded at the proper date will outyield Sunrise kafir when seeded at its best date. The date on which the varietal experiments were seeded has been about the middle of May, except in 1915. This date of seeding has proved to be the best time for seeding Sunrise kafir, but is about one month too early for maximum yields of Dwarf Yellow milo. This accounts for the relatively low yields of the milos in the varietal experiments when compared with Sunrise and Dawn kafirs.

Spacing experiments have been conducted with Dwarf Yellow milo and Sunrise kafir for five years, 1917 to 1921, inclusive. Dwarf yellow milo in rows spaced 44 inches apart made the highest average yield, 27.9 bushels per acre, with 24 inches of row space to the plant. In rows 88 inches apart, the highest average yield, 26.4 bushels per acre, was made by plants spaced 12 inches apart in the row.

With the Dwarf Yellow milo, the rows 88 inches apart with 6.6 inches between plants outyielded the corresponding rate, 13 inches between plants in rows 44 inches apart, by an annual average of 1.5 bushels per acre. In the other four rates the 44-inch rows outyielded the 88-inch rows in the 5-year average.

Sunrise kafir produced the highest average yield, 27.6 bushels, from plats with 12 inches of row space to the plant in 44-inch rows. With rows 88 inches apart the highest average yield for the five years was 23.5 bushels from plants 6 inches apart. Sunrise kafir, in wide-spaced rows, 88 inches apart, does not yield as much grain or total crop as in rows 44 inches apart.

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